



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

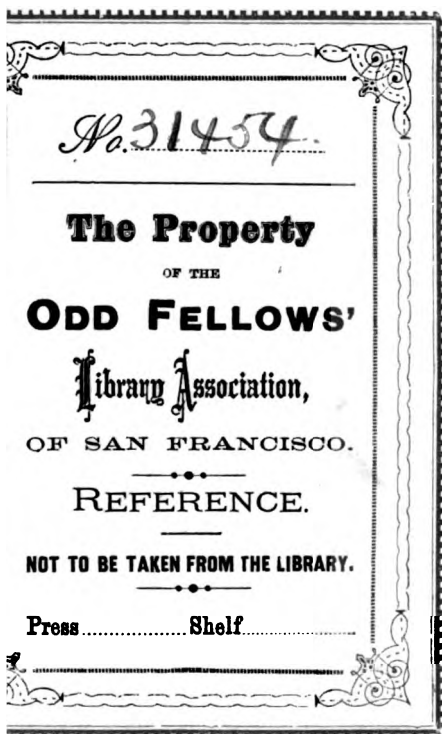
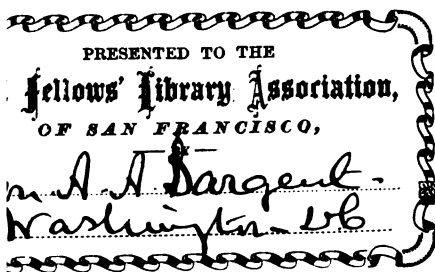
Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>



43D CONGRESS, }
2d Session. }

HOUSE OF REPRESENTATIVES.

{ Ex. Doc. 1,
Part 2.

31454

REPORT

OF THE

SECRETARY OF WAR;

BEING PART OF

THE MESSAGE AND DOCUMENTS

COMMUNICATED TO THE

TWO HOUSES OF CONGRESS

AT THE

BEGINNING OF THE SECOND SESSION OF THE FORTY-THIRD CONGRESS.

VOLUME II.
PART I.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1874.

REPORT
OF
THE CHIEF OF ENGINEERS.

1 E

REPORT OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 20, 1874.

SIR : I have the honor to present for your information the following report upon the duties and operations in the Engineer Department during the fiscal year ending June 30, 1874.

OFFICERS OF THE CORPS OF ENGINEERS.

The number of officers holding commissions in the Corps of Engineers, United States Army, at the end of the fiscal year, was 105 on the active list, and 5 on the retired list; the latter, however, under the law of January 21, 1870, not being available for duty. In the duties devolving upon the corps by law, and its organization, the employment of a number of scientists and assistant engineers has been necessary.

Since my last report the corps has lost by death and retirement three officers, namely : First Lieut. Eugene A. Woodruff, who died at Shreveport, Louisiana, September 30, 1873, of the yellow fever, contracted while devoting himself to the care of the sick during the epidemic of that year; Brig. Gen. Richard Delafield, late Chief of Engineers, (retired,) who died in Washington November 5, 1873; and Colonel George W. Cullum, who was retired, January 13, 1874.

On the 30th of June, 1874, the officers were distributed to duties as follows :

On duty, Office of the Chief of Engineers, including the chief	4
On duty, projection and construction of fortifications	8
On duty, construction of fortifications and light-house duty	2
On duty, construction of fortifications and river and harbor works, and surveys for same	22
On duty, construction of fortifications and river and harbor works, and light-house duty, and surveys for same	4
On duty, construction of river and harbor works, and surveys for same	15
On duty, construction of river and harbor works, and light-house duty, and surveys for same	5
On duty, survey of northern and northwestern lakes	6
On duty, explorations of country west of one hundredth meridian	3
On duty, with battalion of engineers	10
On duty, public buildings and grounds, District of Columbia	1
Detached, on duty with the General of the Army, generals commanding divisions, departments, light-house establishments, Military Academy, survey of northern boundary line under Department of State, superintendent of the United States Naval Observatory, and the board of commissioners of the District of Columbia ..	24
Recent graduates of the Military Academy on leave of absence	1
Total	105

The officers detached were on duty as follows :

Col. I. C. Woodruff, engineer third light-house district	1
Lieut. Col. William F. Reynolds, engineer fourth light-house district	1

REPORT OF THE CHIEF OF ENGINEERS.

Lieut. Col. R. S. Williamson, engineer twelfth light-house district	1
Maj. O. M. Poe, on staff of the General of the Army	1
Maj. H. M. Robert, engineer eleventh light-house district	1
Maj. F. Harwood, engineer fifth and sixth light-house districts	1
Maj. P. C. Hains, engineer-secretary to the Light-House Board	1
Maj. G. L. Gillespie, on staff of Lieutenant-General commanding military division of the Missouri	1
Capt. Asa H. Holgate, on staff of commanding general Department of Texas	1
Capt. William Ludlow, on staff of commanding general Department of Dakota ..	1
Capt. William S. Stanton, on staff of commanding general Department of Platte ..	1
First Lieut. E. H. Ruffner, on staff of commanding general Department of the Missouri	1
First Lieut. J. G. D. Knight, on staff of major-general commanding Military Division of the Pacific	1
First Lieut. R. L. Hoxie, chief engineer of the District of Columbia, under the direction of the board of commissioners	1
Capt. William J. Twining, J. F. Gregory, and First Lieut. F. V. Greene, on duty under Department of State, upon joint commission for the survey of the boundary line along the forty-ninth parallel	3
Capt. C. W. Raymond, First Lieuts. E. W. Bass, and S. E. Tillman, on duty under the superintendent of the United States Naval Observatory in connection with observation of the transit of Venus	3
Capt. A. M. Miller, T. H. Handbury, First Lieut. J. C. Mallery, and Second Lieut. C. F. Palfrey, on duty at the Military Academy	4
Total	24

The following principal civil engineers and geologists were employed on the 30th of June:

General J. H. Wilson, member of board of engineers upon improvement of the Des Moines and Rock Island Rapids, and improvement of the Illinois River; Clarence King, geologist, in charge of geological exploration of the fortieth parallel; and S. Thayer Abert, in charge of river and harbor improvements on Potomac River and Chesapeake Bay.

SEA-COAST AND LAKE-FRONTIER DEFENSES.

The progress during the past year, of the works for the defense of our harbors from naval attacks, has been satisfactory, and some of the works for the protection of the harbors of our principal cities, are approaching completion.

As has been mentioned in my previous annual reports, the class of works now in progress are mainly earthen barbette and mortar batteries, having great thickness and height of parapets, and thorough protection from enfilade and reverse fires, by massive traverses and paradocs. The barbette-batteries for guns are being arranged for the new ordnance-carriage of increased height, but will also be available for the depress-ing-carriage when that shall have been provided.

Every step taken in the location, construction, or modification of our sea-coast defenses is in accordance with the general conclusions and principles agreed upon by the board of engineers in 1869, which received the approval of the Chief of Engineers, the General of the Army, and the Executive, and which have repeatedly commended themselves to the intelligence of Congress.

In comparison with the large number of harbors and anchorages along our coasts, but a limited number are being fortified, and appropriations are asked only for those having sufficient depth of water to admit the entrance of the enemy in iron-clad vessels carrying the powerful rifled modern armaments, and where interests covering millions of dollars would be sacrificed by a successful invasion.

But a small number of our works are what could be called new; that is, planned entirely in accordance with the requirements for resisting

the modern heavy ordnance. Nearly all have been handed down from former periods, when small guns and wooden ships only were to be contended with, and the present operations at these works consist in enlarging and strengthening the earthen portions to resist the heavy rifled shot.

The earthen parts of modern fortifications have assumed such extensive proportions that they are no longer capable of being thrown up and constructed in short and limited periods, while the guns and armaments are of so great dimensions, and so massive, that special machinery, skilled labor, and considerable time are required to place them in position.

Unlike the armaments used in them, no two sea-coast works are of the same model, plan, or *tracé*. Every work is a special one, which must be adapted to the peculiarities of the site, of the harbor, the channel-ways, and of the interests involved in the defense. The preparation of the plan for each site requires careful surveys, investigation, and study; and the time required for construction renders it now imperative that our sea-coast works should be planned and built before the sudden and decisive wars of modern times are either imminent, or actually in progress.

The appropriations for mortar-batteries have been judiciously distributed for the erection of these valuable auxiliaries against iron-clads in five of our principal harbors, and a further appropriation is asked for their continuance.

The trials with torpedoes, which have been in progress at Willet's Point for some years past, have developed a practical and efficient system for the location and operation of this most valuable obstruction to the entrances of our harbors, giving us a means whereby we can hold the enemy's vessels under the fire of our guns, and prevent their running past our batteries.

The system is described more in detail in the body of this report, and consists, as all systems for the defense of harbors should, of stationary torpedoes, both ground and buoyant, exploded either by the medium of the contact of the vessel or by the judgment of the operator. Moving torpedoes, alone, will not answer the purpose of barring the entrances to harbors. To operate this class of torpedo they must either be seen, or the enemy must be in view, and so, just in those periods of fogs or darkness when a daring commander would seek to penetrate a harbor, this class of torpedo would be of no avail against him.

To continue the purchase and storing of such portions of our torpedo apparatus as could not, in event of war, be speedily obtained, the sum of \$150,000 is asked.

No plans of iron shields for casemated defenses have as yet been perfected. In several of our important harbors this class of works will be needed, but the cost of such structures renders it important that they should be designed only for the most powerful rifled ordnance practicable. And until this class of guns, with their carriages, shall have been determined upon by the proper Department, the plans must be delayed.

The progress made and anticipated upon the several works on the coasts is given in detail in the following portions of the report. The estimates submitted, based upon the estimates of the several officers in charge, which have been carefully revised, present those amounts which, in the judgment of this Department, are necessary for the completion, continuance, or commencement of projects for the coming fiscal year.

FORTIFICATIONS.

Fort Wayne, Michigan, in charge of Maj. F. Harwood, Corps of Engineers.—This work was in good condition at the close of the fiscal year. No operations were in progress during the year, and none beyond minor repairs are contemplated during the present year. The perishable equipment and material on hand were sold at public auction, and the watchman discharged. No preparations have been made or are intended for any change in the armament of the work.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Fort Porter, Black Rock, near Buffalo, New York, in charge of Maj. F. Harwood, Corps of Engineers.—This work remains as last reported, excepting additional adornment of the grounds by the city of Buffalo, under act of Congress approved July 11, 1870. Nothing has been done upon the fort during the past year, and nothing is proposed for the present fiscal year.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Fort Niagara, mouth of Niagara River, New York, in charge of Maj. John M. Wilson, Corps of Engineers.—This work is situated at the mouth of the Niagara River, commanding its debouch into Lake Ontario.

During the past fiscal year the operations in progress have been confined to those necessary for the proper care and preservation of the work and materials on hand.

During the present fiscal year it is proposed to relay the brick, where necessary, in the coping of the scarp-wall, to repair the slope-wall protection of the sea-wall at the salient angle of the north bastion, and to make the temporary repairs to the old shore-protection near the north-west angle.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Fort Ontario, mouth of Oswego River, New York, in charge of Maj. John M. Wilson, Corps of Engineers.—This work protects the city of Oswego from a sudden attack or *coup de main*, or the levy of a contribution by a small force of an enemy on shipboard. The work in progress upon the fort is the replacing of the old timber-scarp by more durable materials and the modification of the barbette for the heavy modern ordnance. During the past year the operations in progress have been confined to those necessary for the proper care and preservation of the work and materials on hand. No operations are proposed for the present fiscal year other than are necessary for the preservation of the work.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Fort Montgomery, outlet of Lake Champlain, New York, in charge of Lieut. Col. John Newton, Corps of Engineers.—This work occupies an important strategic point, and commands the entrance to Lake Champlain from Richelieu, or Saint John River.

No operations were carried on during the past fiscal year. Projects for the modification of this work to suit its armament to heavy guns have been prepared by the board of engineers for fortifications, and should be carried out.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Fort Knox, Bucksport, Penobscot River, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—During the past fiscal year no work other

than that necessary for the care of the property having been performed, the condition of this work remains the same as at the close of the fiscal year previous.

No appropriation was made for the fiscal year ending June 30, 1875.
No appropriation asked for next fiscal year.

Fort Popham, Kennebec River, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—During the past fiscal year no operations were carried on, except for the care and preservation of the property, so that the condition of this work remains the same as at the close of the fiscal year previous.

No appropriation was made for the fiscal year ending June 30, 1875.
No appropriation asked for next fiscal year.

Fort Gorges, Portland Harbor, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—During the past fiscal year the plastering of the quarters and the iron-work for the balcony of the gorge were completed. Stone and iron work for the barbette gun-platforms were well advanced.

No appropriation was made for the fiscal year ending June 30, 1875.
No appropriation asked for next fiscal year.

Fort Preble, Portland Harbor, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—During the past fiscal year two permanent platforms in the redoubt, one in the north battery, and one temporary wooden platform in the south battery, were made ready for guns; the traverses and parapets, exclusive of the breast-height walls of the south battery, were completed, and the concrete-magazine, parados, bomb-proofs, breast-height walls, the greater part of the embankments, and the roadway of the north battery were built.

Amount appropriated for the fiscal year ending June 30, 1875	\$20,000
Appropriation asked for next fiscal year	40,000

During the present fiscal year it is proposed to construct all the breast-height walls of the south battery, and complete six additional gun-platforms.

Fort Scammel, Portland Harbor, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—During the past fiscal year the concrete bomb-proof covering, three-fourths of the superimposed embankments, the breast-height walls, and the long concrete communications of the east and west bastions were completed. In the upper level of the main work nearly all the slopes of traverses and parados upon fronts I, IV, and VI were sodded, and all but one of the remaining positions made ready for gun-platforms.

Amount appropriated for the fiscal year ending June 30, 1875	\$30,000
Appropriation asked for next fiscal year	50,000

During the present fiscal year it is expected to complete all but the barbette gun-platforms of the east and west bastions, together with the works in their rear, and to construct breast-height walls and platforms for three guns in the main work.

Battery on Portland Head, Portland Harbor, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This is a new work, upon the most commanding site at the entrance to the main ship-channel to the harbor, three miles below the city. Operations were commenced early in the past fiscal year. The parapet embankment for seventeen guns was mainly filled in, and four of the concrete traverse-magazines, with a greater part of their embankment, were built.

No appropriation was made for the fiscal year ending June 30, 1875.	
Appropriation asked for next fiscal year	\$50,000

During the present fiscal year it is expected to complete two breast-height walls and gun-platforms.

Fort McClary, Portsmouth Harbor, New Hampshire, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—During the past fiscal year three temporary wooden platforms for heavy guns, with a sufficient parapet, on the site of the old circular battery, were nearly completed. Otherwise the condition of the work remains the same as at the date of the last annual report.

No appropriation was made for the fiscal year ending June 30, 1875.
No appropriation asked for next fiscal year.

Fort Constitution, Portsmouth Harbor, New Hampshire, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—During the past fiscal year a temporary position was prepared for one heavy gun in the southwest angle of the old fort, and the platform partially laid.

No appropriation was made for the fiscal year ending June 30, 1875.
No appropriation asked for next fiscal year.

Battery on Gerrish's Island, Portsmouth Harbor, New Hampshire, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—During the past fiscal year the parapet was raised nearly to its full height, and rock excavations for a part of the roadway in rear of the terrepleins and for two of the six traverse-magazines were completed.

Amount appropriated for the fiscal year ending June 30, 1875	\$15,000
Appropriation asked for next fiscal year	35,000

During the present fiscal year it is proposed to prepare the foundations for all the traverse-magazines and to build three of them.

Battery on Jerry's Point, Portsmouth Harbor, New Hampshire, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—During the past fiscal year two-thirds of the parapet-embankment has been raised to its full height, and the earth and rock excavations for the foundations of all the traverse-magazines completed.

Amount appropriated for the fiscal year ending June 30, 1875	\$15,000
Appropriation asked for next fiscal year	35,000

During the present fiscal year it is expected to complete the concrete work of all the magazines and breast-height walls, and make ready all the positions for gun-platforms.

Fort Warren, Boston Harbor, Massachusetts, in charge of Col. Henry W. Benham, Corps of Engineers.—During the past fiscal year operations in bastion A consisted in the completion of the five new 15-inch gun-platforms and their breast-height walls, the completion of the masonry of the two traverse-magazines with the connecting-parados arch, and the necessary doorways, staircases, &c.; about one-half of the earth-cover has been put in place, and the new sand-parapet essentially completed from the salient of bastion A to include three-quarters of the curtain front I. In bastion B, two of the four new 15-inch gun-platforms have been completed, and a third finished except the setting of the pintle and the traverse rails. In the parade of this bastion the foundations of the new arch-piers have been completed. In bastion E, the parados arch has been built, connecting the two traverse-magazines, with entrances, drains, &c., and from each extremity an arched covered stairway has been constructed leading to the flank casemates. An inclined way, (with stationary engine,) from the wharf to the terreplein of this bastion, has been built, to aid in the moving of material. In the demi-lune, of the five new gun-platforms, one is ready for its armament and two others are ready except iron-work. The breast-height wall for the

whole battery has been built, and considerable progress made with the new sand-parapet.

No appropriation was made for the fiscal year ending June 30, 1875.

Appropriation asked for next fiscal year..... \$50,000

Battery at Long Island Head, Boston Harbor, Massachusetts, in charge of Col. Henry W. Benham, Corps of Engineers.—During the past fiscal year, owing to the exhaustion of funds, work was confined to the latter part of the season, and resulted in the completion of the center pintle 15-inch gun-platform at the east salient of the battery, as also of the masonry of the adjacent magazine and parados, excepting the doorways connecting with the batteries and covered way.

Amount appropriated for the fiscal year ending June 30, 1875..... \$40,000

Appropriation asked for next fiscal year..... 50,000

Fort Winthrop, Boston Harbor, Massachusetts, in charge of Col. Henry W. Benham, Corps of Engineers.—During the past fiscal year fourteen front-pintle platforms, with their breast-height walls, in the east and south batteries, were finished; two others, with their breast-height walls, were completed, except iron-work, and four more finished except iron-work and about half of the breast-height wall, thus completing the platforms for forty four 15-inch guns upon these works. The new sand-parapet of the east battery was also completed, and much of the excavation necessary for that of the south battery was executed. Two new traverse-magazines in the south battery were entirely finished, and a third advanced to the completion of its masonry and about one-half of its earth cover.

No appropriation was made for the fiscal year ending June 30, 1875.

Appropriation asked for next fiscal year..... \$50,000

Fort Independence, Boston Harbor, Massachusetts, in charge of Col. Henry W. Benham, Corps of Engineers.—During the past fiscal year one new 15-inch platform for the enceinte, and the iron-work of fourteen others were completed, thus finishing, ready for armament, the whole of the new barbette-battery. The new sand-parapet, the traverse-magazines, and parados of fronts I and II, and the two traverse-magazines on front III, were completed, as also the excavations for the sand-parapet. In the east exterior battery, the most eastern gun-platform, with its breast-height and sustaining walls, was completed as to its masonry.

No appropriation was made for the fiscal year ending June 30, 1875.

Appropriation asked for next fiscal year..... \$45,000

Fort at Clark's Point, New Bedford Harbor, Massachusetts, in charge of Maj. G. K. Warren, Corps of Engineers.—Nothing was done at this work during the past fiscal year, except some needed repairs to the buildings to protect them from decay.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Fort Phoenix, New Bedford Harbor, Massachusetts, in charge of Maj. G. K. Warren, Corps of Engineers.—No work was done during the past fiscal year.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Fort Adams, Newport Harbor, Rhode Island, in charge of Maj. G. K. Warren, Corps of Engineers.—During the past fiscal year the concrete of six magazine-traverses, with their partitions, was completed. The parapet, in front of a space to contain fourteen guns, was carried up to

give a breast-height of seven feet, and the terreplein graded. A new wharf, convenient to the work, and in quiet water, was constructed as far as it was necessary to make it available, and a substantial roadway made to connect it with the battery by means of rails and cars, as well as by ordinary vehicles. A large culvert, suitable for electric cables, was constructed under the terreplein and parapet, and a thorough system of drainage completed.

The appropriation asked for the fiscal year ending June 30, 1876, contemplates the completion of the emplacements for six more heavy guns, building one set of quarters, and repairs to the present quarters, to the main work, and to the permanent or north wharf.

Amount appropriated for the fiscal year ending June 30, 1875.....	\$20,000
Appropriation asked for next fiscal year.....	30,000

During the present fiscal year it is proposed to complete the emplacements for four heavy guns, and to lay the foundations for the platforms and breast-height wall of two more guns.

Dumpling's Battery, Canonicut Island, Rhode Island, in charge of Maj. G. K. Warren, Corps of Engineers.—No work has been done at this site during the past fiscal year, no appropriation having been made for the work.

It is proposed to construct this battery for heavy guns on the site of the ruins of an old casemated tower, built about the close of the last century on Canonicut Island, opposite Fort Adams.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Defenses of Dutch Island, western entrance to Narragansett Bay, Rhode Island, in charge of Maj. G. K. Warren, Corps of Engineers.—During the past fiscal year four magazine-traverses have been covered in with sand and properly sodded. The parapet for a breast-height of seven feet, connecting them, has been completed. A scarcity of water compelled the construction of a reservoir to store surface rain-water, one large common well, and a drilled well on the summit of the island, which penetrates one hundred and twenty feet below the surface. Brick drains with suitable man-holes and gratings have been nearly completed. Necessary repairs to tools, boats, carts, cars, railroad track, and roads were made. The rubbish, stone, &c., in rear of the new battery were removed, and the place plowed and sowed in grass. Large quantities of bowlders were deposited on the northwest shore to check further inroads of the waves. A survey was made showing changes in shore-lines since survey of 1862, and a complete set of records of Dutch Island was compiled, extending from the first occupation of the island by the United States for military purposes, in 1863, down to date.

The appropriation asked for the fiscal year ending June 30, 1876, contemplates the completion of emplacements for four more heavy guns, the building of two needed storehouses, and the construction of a road around the island.

Amount appropriated for the fiscal year ending June 30, 1875.....	\$20,000
Appropriation asked for next fiscal year.....	40,000

During the ensuing fiscal year it is proposed to complete the platforms and breast-height walls for four heavy guns, and raise the parapet eleven feet above the terreplein.

Fort Trumbull, New London Harbor, Connecticut, in charge of Maj. G. K. Warren, Corps of Engineers.—Nothing has been done here during the past fiscal year, except some minor repairs. It is designed to mod-

ify the exterior batteries so as to mount heavy guns. It is desirable, also, to alter the pintles and chassis of the main work, so as to admit of mounting 10-inch and equivalent rifle cannon.

Amount appropriated for the fiscal year ending June 30, 1875.....	\$25,000
Appropriation asked for next fiscal year.....	40,000

During the present fiscal year it is proposed to prepare for the battery of heavy guns.

Fort Griswold, New London Harbor, Connecticut, in charge of Maj. G. K. Warren, Corps of Engineers.—No work has been done here during the past fiscal year. It is designed to modify this battery so as to mount 15-inch guns or equivalent rifle cannon.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Fort Hale, New Haven Harbor, Connecticut, in charge of Maj. G. K. Warren, Corps of Engineers.—No work has been done here during the past fiscal year. The jetty which was begun the year before at right angles, nearly, with the shore, made of stone taken from Luddington Rock, was designed to cause the beach material to close the breach in the ditch of the fort. This it accomplished during the past winter. The fort is abandoned.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Fort Schuyler, East River, New York, in charge of Maj. H. L. Abbot, Corps of Engineers.—During the past fiscal year, in the main work, north front, the earthen parapet has been embanked and exterior slope sodded; two center-pintle platforms for 15-inch guns have been laid; traverse-magazine No. 1 has been completed, and sodded, except the portion extending over parapet; traverse-magazine No. 2 has been built, covered with mastic, and partly covered with sand; a small part of breast-height wall has been built.

On the northeast front, the parade-wall has been finished, and coping of scarp-wall set; the unfinished pier completed; the casemate arches have been covered with mastic, and partly with sand; all the valley-drains have been made; traverse-magazine built and partly covered with mastic.

On the southeast front, the abutment pier has been completed, two other piers built, and the third raised to the sixth course. Two stone arches have been turned; the brick arches in east angle and one casemate-arch have been built, and a second commenced. The old parade-wall, stone parapet, and gun-platforms have been removed; the scarp-wall has been nearly prepared for the coping, all of which has been cut. Stone, brick, and concrete-stone for completing the front have been purchased.

In the ten-gun battery, the parapet, traverses, epaulment, and paradoss in rear of two west guns have been graded and sodded, and the magazine doors prepared. About one-half the parapet has been built; a short section of sea-wall, serving for the protection of the west angle, has been begun.

The wharf has been thoroughly re-covered with plank, and a drop added.

Amount appropriated for the fiscal year ending June 30, 1875.....	\$25,000
Appropriation asked for next fiscal year.....	50,000

During the present fiscal year it is proposed to devote all available funds, after putting the ten-gun battery in a fit condition to await completion hereafter, to the main work. One front pintle-platform for 15-inch gun in the west angle of the north front will be laid, and

breast-height walls in front of it, and of the two center-pintle platforms for 15-inch guns already laid, will be completed. As far as practicable, the appropriation will be expended with a view to putting the barbette tier into a condition for immediate service.

Fort at Willet's Point, eastern entrance to New York Harbor, in charge of Major H. L. Abbot, Corps of Engineers.—During the past fiscal year, in the west battery, concrete foundations have been laid for one 15-inch front-pintle gun-platform, and the sea-wall has been completed.

In the middle battery, about 3,000 cubic yards of earth-filling in parapet and about 1,000 superficial yards of sodding of exterior slopes have been completed. Concrete foundations have been laid for four 15-inch front-pintle gun-platforms and for two 15-inch center-pintle gun-platforms. Two of the four 15-inch front-pintle gun-platforms are nearly ready for mounting the guns. The sea-wall has been completed. Four concrete storage-casemates for torpedo cables in rear of the eastern part of the battery and the extension of underground passage-way have been completed.

In the east battery, about 6,000 cubic yards of earth have been placed in the parapet. One traverse-magazine has been built and covered with earth to grade, and two others have been covered with earth in part. The mortar battery has been completed, and platforms are nearly ready for mounting the four 13-inch mortars on hand.

It is proposed to continue the construction of storage-casemates, and to prepare platforms for three 15-inch guns and for the four 13-inch mortars, and also to prepare the torpedo-casemate as planned by the board of engineers and duly approved.

Amount appropriated for the fiscal year ending June 30, 1875	\$30,000
Appropriation asked for next fiscal year	50,000

Fort Columbus, Governor's Island, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers.—During the past fiscal year no work has been done except the replacing of the floor of the drawbridge at the entrance of the fort with new plank.

No appropriation was made for the fiscal year ending June 30, 1875.
No appropriation asked for next fiscal year.

New Barbette Battery at Fort Columbus, Governor's Island, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers.—No work has been done here during the past fiscal year.

No appropriation was made for the fiscal year ending June 30, 1875.	
Appropriation asked for next fiscal year	\$50,000

Castle William, Governor's Island, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers.—Nothing has been done at this work during the past fiscal year.

South Battery, Governor's Island, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers.—Nothing has been done at this work during the past fiscal year, except the extension of the permanent drain to the beach.

Fort Wood, Bedloe's Island, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers.—During the past fiscal year work has been confined to grading and sodding the magazines, raising the parapet, and putting in drain.

No appropriation was made for the fiscal year ending June 30, 1875.
No appropriation asked for next fiscal year.

Fort Hamilton and additional batteries, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers.—During the past fiscal year

in battery No. 1, magazines Nos. 1, 2, 3, and 4, have been completed and sodded, the drains put in, the terreplein graded to its proper level, and the parapet raised to an average elevation of reference, (18').

In the 15-inch gun-battery all the 5-inch pintles have been taken out and replaced with 6-inch pintles.

Amount appropriated for the fiscal year ending June 30, 1875.....	\$26,000
Appropriation asked for next fiscal year.....	15,000

Mortar Battery at Fort Hamilton, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers.—During the past fiscal year the main drain has been completed, the exterior slopes have have been sodded, and three magazines supplied with doors. Five wooden platforms have been laid, and concrete foundations for the remaining eight platforms have been put down.

Fort Wadsworth, Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gilmore, Corps of Engineers.—During the past fiscal year, the only operations carried on at this work consisted in replacing the old pintles with new 4-inch pintles in the six-barbette gun-platforms, Nos. 22 to 27, inclusive..

No operations are contemplated during the present fiscal year.

One of the casemates of this work is to receive some alterations to adapt it to the requirements of torpedo defense. The ditch on the land side requires cleaning out, all the embrasure irons need painting, and a large portion of the masonry of the work requires pointing. It has never been pointed.

No appropriation was made for the fiscal year ending June 30, 1875.

Appropriation asked next fiscal year.....	\$7,000
---	---------

Fort on site of Fort Tompkins, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—During the past fiscal year the ten timber platforms, for the authorized armament of the channel front, have been laid upon concrete foundations, and a masonry breast-height wall for the same constructed; thirteen wooden ceilings have been put in the second-tier casemates, and seven floors laid, thus completing the interior finish of the casemate quarters in the south half of the work, with the exception that eleven of them have yet to be glazed. Seven second-tier casemates in north face have been furred off with brick. A flagged sidewalk of nine feet four inches wide, with bluestone curb and gutter, and a macadamized road thirteen feet wide, with suitable cess-pools and drains, have been constructed around the entire parade next the parade wall, except on the channel front. Cast-iron conduct pipes have been placed in the casemate piers of channel front to conduct the water falling upon the casemate roofs into the cisterns. Five solid doors have been made and hung in service magazines. The glacis north-west of the fort has been graded and seeded down; the earth-filling of cover-face on channel front has been finished with the exception of fifty feet in length at each end, and the slope of the cover-face next the work graded and sodded.

A large quantity of earth washed down from the main slope between the fort and the north-cliff battery, has been returned to the foot of the slope where required.

Amount appropriated for the fiscal year ending June 30, 1875.....	\$30,000
Appropriation asked for next fiscal year.....	75,000

During the present fiscal year the side-walls of south sally-port will be constructed, and the sally-port paved; the solid gates of sally-ports will be made and hung. All the magazine-doors and lamp-closets will be completed, and a macadamized road constructed along the parade-

wall of channel-front. The parade will be graded and seeded down during the present working-season. The brick furring of casemate-quarters will be completed. The cover-face on channel-front and the macadamized road between it and the scarp-wall will be finished.

Amount required, in addition to the existing appropriation, to complete Fort Tompkins, and North Cliff and South Cliff batteries, in accordance with approved plans, \$100,000.

In this amount is included the sum of \$25,000 to be applied to the large casemates on the channel-front of Fort Tompkins, in paving them with concrete and building fire-places, and parade and partition walls, with doors, windows, &c., according to the official plan. Extensive repairs to slopes have been necessary during the past spring, in Fort Tompkins and in the Glacis gun battery, and the North Cliff battery.

Glacis Gun-Battery, (north of fort on site of Fort Tompkins,) Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This battery was reported in readiness to receive its armament in the last annual report. The magazine-doors and lamp closets have not yet been entirely finished, but will be during the present working season.

No appropriation is asked.

Glacis Mortar-Battery, (south of fort on site of Fort Tompkins,) Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This battery has received its armament. A little unfinished work upon the lamp-closets and magazine-doors is now in progress, and will be finished during the present working-season.

No appropriation is asked.

Battery Hudson, Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—During the past fiscal year, six of the guns forming the old armament on the east face were dismounted, and their platforms removed, and in place thereof five permanent front pintle-platforms, with low traverse rails, and the corresponding breast-height wall for the approved armament, constructed. Two drains of 8-inch glazed pipes were built from the interior of the battery down to the river to drain terreplein. The masonry in the five feet and in the four feet arched passage-ways leading to the south and the north principal magazines was finished, except the coping for the entrance retaining-walls, and the earth cover over these magazines partially formed. Six-inch pintles, with keys, have been inserted in all the permanent platforms. In the south branch of the old battery, four timber front pintle-platforms, with high traverse rails, for the approved armament, have been laid, and all the magazine doors (except three grated doors) made and hung. In the extension, five timber-platforms, with high traverse rails, for the approved armament, have been laid, and the breast-height in front of them temporarily revetted with sods.

Amount appropriated for the fiscal year ending June 30, 1875.....	\$13,000
Appropriation asked for next fiscal year	26,000

(The estimate of \$26,000 for completing the work is designed to cover the \$17,500 covered into the Treasury, and the construction of stone breast-height walls in positions for which temporary revetments were formerly contemplated.)

During the present fiscal year Battery Hudson and its extension will be finished, with the exception of five permanent platforms for large guns on the east face, and the necessary breast-height wall for those guns, and also for nine others on the south face where temporary revetments were formerly contemplated, and some of which have already been built.

The new estimate includes the cost of permanent platforms for the new ordnance carriage and masonry breast-height walls for all positions, and not included in any previous estimate.

South Mortar Battery, (in rear of Battery Hudson extension,) Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—During the past fiscal year all the masonry and earthwork of this battery were finished, and the area in rear graded and seeded down. Two outer magazine-doors made and hung, and a strong picket-fence erected along the road so as to inclose the rear of the battery. The work yet to be done to finish the battery consists in constructing and laying eight timber mortar-platforms, upon concrete foundations now in place, and the fitting up of two inner magazine-doors and two lamp-closets.

North Cliff Battery, Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—During the past fiscal year the operations have consisted in completing the addition of masonry and earthwork to the traverse-magazine south of the north principal magazine, in laying four concrete foundations for timber gun-platforms, and laying two of the platforms. The outer solid magazine-doors have all been made and hung. A macadamized road leading to Fort Wadsworth has been made and provided with suitable gutters. During the present fiscal year the two timber gun-platforms not yet laid, in consequence of their having been required elsewhere for experimental firing, will be put down, and the temporary breast-height wall finished. The battery will be in readiness to receive its entire armament during the present working season. The parapet will have to be thickened and the slope next the river finished from some future appropriation.

No separate appropriation is asked for this battery.

South Cliff Battery, Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—No work was done upon this battery during the past fiscal year beyond that necessary to keep it in good order. The authorized modification will be commenced as soon as funds are provided for the purpose, the estimates being included in those for fort on site of Fort Tompkins.

No separate appropriation is asked.

Fort at Sandy Hook, New Jersey, in charge of Lieut. Col. John Newton, Corps of Engineers.—A temporary battery for six guns was ordered to be constructed, but the funds allotted therefor having reverted to the Treasury under the decision of the First Comptroller, nothing was done beyond selecting the site and having the wooden platforms constructed.

During the past fiscal year one jetty, 109 feet long, was built, and appearances are favorable for the preservation of the site, with occasional attention to repairs of jetties.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Fort Mifflin, Delaware River, Pennsylvania, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—During the past fiscal year the south battery of the demilune has been completed, and the platforms made ready for the guns; the dike along the south boundary-line was completed. Exterior battery embanked for three-fourths of its length and partly graded; repairs made to the wharf, dike, large magazine on parade, and to the roof of main gateway entrance.

No appropriation was made for the fiscal year ending June 30, 1875.

Appropriation asked for next fiscal year..... \$50,000

During the present fiscal year nothing can be done except to complete

the embanking of the exterior battery, and maintain general care and supervision over the dikes, bridges, and works.

During the next fiscal year it is proposed to complete the exterior battery, commence battery on the north face and new storage magazine in the demilune, and make necessary repairs to dikes, roads, and buildings.

Mortar Battery at Fort Mifflin, Delaware River, Pennsylvania, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—During the past fiscal year repairs have been made to the mastic covering of the magazines, a sand-traverse formed over each, a temporary drain dug, the flooring and door of the north magazine placed, and a door fixed on the south magazine.

No appropriation was made for the fiscal year ending June 30, 1875.

Site for the defenses at Red Bank, New Jersey, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—During the past fiscal year repairs have been made to the dikes, buildings, sluice, and fences, and general care and supervision exercised.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Fort Delaware, Delaware River, Delaware, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—This work is on Pea Patch Island, and, with the batteries at Finn's Point and on the Delaware shore, forms the outer line of defense for the Delaware River.

During the past fiscal year the three remaining wooden platforms of the barbette tier, for 15-inch guns, have been put down; the breast-height wall and parapet in front of them have been finished; the doors of the barbette service-magazines have been hung, and the floors laid; the steps and coping have been completed, and storm-sheds built over the entrances; a leak under one of the new platforms has been stopped; the iron balconies in rear of magazine-traverses have been commenced; the tops of four stair-towers have been removed to make room for mounting guns; a new flag-staff has been erected; the old pintle and traverse rail of one of the barbette platforms for ten-inch guns has been replaced with a keyed pintle and heavy rail; the iron shield used in experimental firing has been removed, and the rebuilding of the embrasure and closing of the breach commenced; the thorough cleansing of the ditches of the island, and repairs of dike, have been completed; the wharves have been partially repaired, and preparations have been made for building a stone top to upper eastern wharf.

Amount appropriated for the fiscal year ending June 30, 1875.....	\$25,000
Appropriation asked for next fiscal year.....	25,000

During the present fiscal year it is proposed to complete the iron balconies, to rebuild embrasure No. 17, and close breach in scarp; to repair the flagging of parade-walk, to build temporary sheds over stair-towers, and to commence the stone superstructure of upper eastern wharf.

Battery at Finn's Point, Delaware River, New Jersey, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—During the past fiscal year the wharf has been completed; the parapet of the battery has been embanked to the level of the terreplein for a distance of 300 feet south of mortar battery; the shelter room and magazine at intersection of gun and mortar batteries have been commenced; a retaining wall for exterior slope of right wing has been built; the dike at the upper part of the United States land has been extended from the wharf south to the boundary-line. Two wooden platforms for 15-inch guns, and three for 10-inch guns have been placed in temporary positions.

Amount appropriated for the fiscal year ending June 30, 1875.....	\$30,000
Appropriation asked for next fiscal year.....	40,000

During the present fiscal year it is proposed to complete the shelter-room and magazine; to construct one other magazine, and the traverses of both; to embank the parapet for 350 lineal feet from mortar-battery; to complete four platforms for 15-inch guns, and to build the breast-height wall in front of two of them.

Mortar Battery at Finn's Point, Delaware River, New Jersey, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—During the past fiscal year the sea-wall supporting the exterior slope of parapet has been completed, and the embankment behind it has been brought to nearly the level of the top; the terreplein has been embanked; the masonry of two magazines has been finished; the mastic roofing put on, and their traverses sufficiently embanked to protect the masonry from frost. The positions of three of the platforms are temporarily occupied by 10-inch guns.

No appropriation was made for the fiscal year ending June 30, 1875.

Fort opposite Fort Delaware, Delaware shore, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—During the past fiscal year the dike along the river-front has been completed, a sluice-way built, and the ground behind it partially graded; the right wing of the battery has been completed to a little above the terreplein; two wooden platforms for 15-inch guns have been laid, one magazine built, and the breast-height wall commenced. The front of the battery has been embanked to an average height ref. (16'), or six feet below level of terreplein. The fencing of the grounds has been finished, a shed for stone-cutting has been built, and a crane erected on the wharf.

Three wooden platforms for 10-inch guns have been constructed temporarily on the terreplein of the mortar-battery.

Amount appropriated for the fiscal year ending June 30, 1875.....	\$30,000
Appropriation asked for next fiscal year.....	40,000

During the present fiscal year it is proposed to complete the right wing of the battery, including two gun-platforms; and, on the front, to complete embankment for 250 lineal feet from mortar-battery; to build shelter-room and magazine with their covering traverse; to put down two wooden gun-platforms; and to build the breast-height wall in front of them.

Mortar-battery near Delaware City, Delaware, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—During the past fiscal year the terreplein of this work has been formed; two magazines have been nearly completed, and their traverses sufficiently embanked to protect the masonry from the weather. The exterior slope of the battery has been made and sodded up to 2 feet above the terreplein, and the body of the parapet has been embanked to 7 feet above. The positions of three of the platforms are temporarily occupied by 10-inch guns.

No appropriation was made for the fiscal year ending June 30, 1875.

Fort McHenry, Baltimore Harbor, Maryland, in charge of Maj. Wm. P. Craighill, Corps of Engineers.—This work forms part of the inner line of defense of Baltimore and its dependent interests, and commands with its fire the interior water of the harbor and the channel of approach thereto.

During the working-season of 1873 and 1874, within the fiscal year, a large force was employed on front No. 4 of the new earthen battery, building the parapet and the heavy embankment for the terreplein, besides constructing the concrete work of three magazines and completing the necessary drains for that portion of the work. At the close of the fiscal year, when operations were closed for want of funds, the terrepleins had

been brought up to grade, the parapet of sand, with sod revetment, completed to a height of 11 feet above terreplein for a length of 400 feet from angle 4-5, affording an excellent position and cover and magazine accommodation for eight or ten 15-inch or equivalent guns.

No appropriation was made for the fiscal year ending June 30, 1875.

Appropriation asked for next fiscal year..... \$50,000

The appropriation asked for the fiscal year ending June 30, 1876, contemplates the continuation of the parapet and terreplein embankments, and the construction of additional magazines, leaving the preparation of gun-platforms until the earth-work has settled, as the subsoil is unstable.

Fort Carroll, Baltimore Harbor, Maryland, in charge of Maj. Wm. P. Craighill, Corps of Engineers.—This fort is situated upon an exterior line of defense, for the harbor of Baltimore. It is a casemated work, and until the best method of arranging such defenses shall have been devised no expenditures upon it are proposed other than for its preservation. During the past winter one wooden center-pintle platform for a 15-inch gun was laid at one extremity of front 6, and a temporary parapet erected in front of it. A second similar platform was framed, but was not laid down. One 15-inch gun, on a center-pintle carriage, has been added to the armament, and needed repairs have been made to the work. The funds used were supplied from the appropriation for contingencies of fortifications.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Obstructions of the Potomac, in charge of Maj. Wm. P. Craighill, Corps of Engineers.—It has not yet been found practicable to make experiments upon these obstructions, for which the co-operation of the Navy Department seems necessary. The material has continued in store at Fort Foote.

Fort Foote, Potomac River, Maryland, in charge of Maj. Wm. P. Craighill, Corps of Engineers.—This work is on the inner line of defense of the channel-approach by water to Alexandria, Washington, and Georgetown. The site is high, commanding, and unusually favorable. During the past fiscal year the grading of the incline and the railway from the wharf to the work has been completed. The earth-embankments of the parapets of the center-pintle guns in the right salient and of the front-pintle guns on the right front, have been made, and the exterior slopes have been sodded. The embankment of the traverse magazines on the left has been commenced. An engine has been placed in position, and an engine-house and cars have been built. The removal of the surplus earth has been continued. The old drains from the right and river-fronts have been reopened, and the former has been rebuilt. Drains have been built to carry off the rain-fall from the center-pintle gun position, and for the drainage of the magazines near the right salient. The masonry of the magazines in the right salient has been commenced, and that of the traverse-magazine on the left of the river-front has been completed, except wing-walls to entrances. The wharf has been extended 110 feet to 10 feet depth of water. The foundations for four front pintle gun-platforms have been completed, and the stones of two of them have been set, and the pintle-blocks of the other two have been placed in position. Steps were taken to open a communication to the Piscataway road for the convenience of the garrison. This object is now nearly accomplished.

No appropriation was made for the fiscal year ending June 30, 1875.

Appropriation asked for next fiscal year..... \$35,000

Fort Washington, Potomac River, Maryland, in charge of Maj. Wm. P. Craighill, Corps of Engineers.—This fort occupies a very important position on the outer line of defense of the cities of Alexandria, Washington, and Georgetown, and their dependent interests. The site is an excellent one, but the line requires strengthening by the introduction of guns of the heaviest calibre, for which the old fort was not suited.

During the past fiscal year work has been confined to the demi-lune. The masonry of the traverse magazine has been completed with the exception of the coping of wing-walls of entrances, and the entrance from the center-pintle gun. The embankment and sodding of the traverse-magazines near the rear extremities of the faces have been completed, as far as can be done till the construction of the breast-height walls. The embankment of the traverse-magazines near the salient, and of the central bomb-proof, has been partially made, and the masonry of the central bomb-proof has been commenced. Timbers for two wooden platforms have been stored at Fort Monroe. The front pintle-platforms on the left face have been commenced; the two platforms between the traverse-magazines have been completed, except the flagging-stones, and the setting of the pintles. The platform on the left of the traverse-magazine, at the rear extremity of the left face, and the right platform of the set of two between the traverse-magazines on the right face, were commenced and completed, with the exception of the setting of the prop-stones next the breast-height, the flagging-stones, and the pintles. An engine and a pump were purchased and placed in position, and an engine-house was built. Proceedings are nearly completed for gaining the title to an adjoining tract of about 300 acres.

No appropriation was made for the fiscal year ending June 30, 1875.

Appropriation asked for next fiscal year, \$35,000 \$35,000

Fort Monroe, Old Point Comfort, Virginia, in charge of Maj. Wm. P. Craighill, Corps of Engineers.—This extensive work occupies an important position, covering the approach to Hampton Roads, the navy-yard at Portsmouth, and the James River. During the past fiscal year, in the place of arms, the sod, soil, and old breast-height were removed, and this battery commenced; the masonry of the magazine was completed; the foundations for two gun-platforms were completed, most of the stones prepared, one of the pintle-blocks placed in position, and the other placed on its foundation. The foundation for a third gun-platform was commenced. In the redoubt, the hauling and placing of sand were continued; the masonry of the traverse-magazines has been completed, and the left magazine almost completed. Stone and timbers for platforms, and material of various kinds, have been received. A cistern has been built with a capacity of about 13,000 gallons, and the cisterns at the carpenter's shop and stable-yard have been secured, repaired, and supplied with pumps. A shed for the protection of timber and material and a bin for coal have been built. An examination has been made of the scarp-wall of front IV for the information of the board of engineers for fortifications. The small wharf opposite front VII has been extended, and the draws of the north and east bridges have been rebuilt. A stone-breaker has been purchased, about 900 feet of railroad-track has been put down, 1,868 feet of fence have been built and painted, and various repairs made about the works.

A project for a battery of ten guns of the heaviest caliber, exterior to fronts II and III, has been prepared by the board of engineers for fortifications, and approved by the Secretary of War. The project for a continuous battery on fronts I, II, III, and IV of the main work has been

rejected, and a new project for a battery of two guns has been made and approved.

Attention is invited to the insufficient supply of water and to the need of quarters for the troops.

Amount appropriated for the fiscal year ending June 30, 1875.....	\$30,000
Appropriation asked for next fiscal year	50,000

Artesian well at Fort Monroe, Virginia, in charge of Maj. Wm. P. Craig-hill, Corps of Engineers.—This well is now 900 feet deep, but no work has been done on it during the past year from want of funds. It is proposed, when funds are available, to increase the depth to 1,200 feet, at which point, as competent geologists have stated, there is a reasonable prospect of obtaining good water. The present supply of water at the fort is insufficient and expensive, and it is a matter of grave importance to have a supply of water which will be ample and unailing, especially in time of war.

No appropriation was made for the fiscal year ending June 30, 1875.
No appropriation asked for next fiscal year.

Fort Wool, Hampton Roads, Virginia, in charge of Maj. Wm. P. Craig-hill, Corps of Engineers.—This casemated fortification unites with Fort Monroe, in closing the passage to Hampton Roads, crossing its fire with the guns from that fort.

Until approved projects for its completion are devised, no further work is contemplated than is necessary to preserve it from injury. Three watchmen have been in charge since September, 1870.

Fifty-two iron-throated casemates of the first tier are ready for guns, and in an emergency several 15-inch guns could be advantageously and promptly mounted in barbette.

No appropriation was made for the fiscal year ending June 30, 1875.
No appropriation asked for next fiscal year.

Fort Macon, Beaufort Harbor, North Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—The subject of the modification of this work is still under consideration.

During the past fiscal year it has been found necessary for the protection of the site to construct a breakwater-dam west of the wharf, where a breach had been made by the tide across the beach to the marsh. Subsequently a crib-jetty was constructed east of the wharf to stop the erosion of the shore there. Both of these works appear to answer the purpose for which they were built. The wharf itself requires some repairs. The casemates of the work require a thorough overhauling to render them fit quarters for officers and enlisted men, for which they are now used.

No appropriation was made for the fiscal year ending June 30, 1875.
No appropriation asked for next fiscal year.

Fort Caswell, mouth of Cape Fear River, North Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This fort, at the mouth of the entrances to Cape Fear River, is advantageously located for the defense of the city of Wilmington. It requires extensive modifications to adapt it to the approved ordnance of the present day. The subject of its modifications is still under consideration.

No appropriation was made for the fiscal year ending June 30, 1875.
No appropriation asked for next fiscal year.

Fort Moultrie, Charleston Harbor, South Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—During the past fiscal year the masonry of magazine in N. E. bastion, for the service of guns 1 and 2, has been constructed, and wing-walls, lintels, and caps have been

added to three other service-magazines, built the previous fiscal year, between positions 4 and 5, 6 and 7, and 8 and 9, respectively. More than three-fourths of the earth-covering of the 1st, 2d, and 4th of these magazines have been roughly filled in, and that of the third (between positions 6 and 7) has been formed to the true slope and seeded down. The concrete masonry of the bomb-proof gallery, east of the sally-port gallery, has been completed, and for twenty feet west of it has been raised to springing-line of arch. East of sally-port gallery the earth-filling has been carried to ref. (5'-6"). The sally-port gallery has been raised to (5' 6") between the bomb-proof gallery and parade-entrance. The terre-plein in rear of guns 5 and 6 has been graded to its proper reference, as has also that of the N. E. bastion. The parapets in rear of positions 9, 10, and 11 has been raised from (0') to (14'). The old breast-height wall and sally-port on north face have been removed, and the scarp-wall on that face and of the N. W. and N. E. bastions raised to required height and coped throughout with artificial stone, excepting over the break left for new sally-port.

Seven timber platforms for the approved armament have been laid in positions 1, 2, 3, 4, 9, 10, and 11. The temporary breast-height wall of sod for guns 9, 10, and 11 has been raised to its proper height, but the parapet has been only partially filled in. A brick breast-height wall has been built in front of gun No. 1. In rear of the fort, platforms for four of our largest sea-coast mortars have been laid on concrete foundations, and the mortars mounted thereon.

Amount appropriated for the fiscal year ending June 30, 1875.....	\$20,000
Appropriation asked for next fiscal year.....	40,000

During the present fiscal year the masonry of the bomb-proof gallery parallel to north face, and the sally-port and gallery on that face, will be completed, and the earth-covering of the principal magazine on east face will be finished and seeded down, and all the magazine-doors will be constructed and hung, except those for the old storage-magazine in N. W. bastion.

Fort Sumter, Charleston Harbor, South Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—During the past fiscal year repairs to the nine casemates of the N. E. face, one in the pan coupé of N. E. and N. faces, and one adjacent thereto in the N. face, have been completed, and one retaining-wall built and earth-filling in rear of same finished. The floors of these eleven casemates, and the scarp-walls and embrasures pertaining thereto, have been repaired, and their armament of eleven guns mounted. The piers of the four northerly casemates of N. W. face have been re-inforced, the scarp-wall of same face has been repaired, and the old temporary sally-port bricked up and replaced by an embrasure. The nine casemates retained in the N. W. face have had their arches repaired and prepared for concreting and asphalting, and retaining-walls have been built to five of them.

The masonry of the new sally-port gallery and connecting service magazines has been completed, with the exception of that of the barbette-magazine, (serving guns Nos. 1, 2, and 3,) and the two loop-holed jambs adjoining casemates. The old cistern under the sally-port casemate has been repaired and strengthened, and two casemates, one on either side of sally-port, have been provided with open wood fire-places and chimneys. Outside, a substantial road has been constructed from the new sally-port to the wharf and extended to the old sally-port in gorge face.

The scarp-walls of S. E. face and the pan coupé between S. E. and

gorge faces, and about twenty feet of that of gorge-face, have been coped with artificial stone, the parapet formed, and its exterior slope set with grass-plants.

The scarp-wall, N. E. face, has been raised to proper reference, and coped for thirty feet from N. E. angle; the scarp-wall of N. W. face has been raised to proper reference for coping for nearly its entire length. The casement-arches, N. E. face, have been covered with concrete, and drain-pipes put in leading to cistern of 20,700 gallons capacity, built in rampart at angle of N. and N. E. faces.

The two barbette service-magazines at angle of N. and N. E. faces and on N. E. face have been built, and about three-fourths of their earth-covering filled in. The foundations for storage-magazine have been put in. The terreplein of N. E. face has been completed, and its parapet filled in to the height of the scarp-wall. Timber gun-platforms for fifteen-inch guns have been laid in positions Nos. 6, 7, and 8, and a brick breast-height wall built for No. 8. Temporary sod-revetted breast-height walls for Nos. 6 and 7 have been carried up to within two feet of ultimate reference. The site of position No. 3 has been filled in and packed ready for platform-foundation.

Amount appropriated for the fiscal year ending June 30, 1875.....	\$20,000
Appropriation asked for next fiscal year.....	40,000

During the present fiscal year it is proposed to finish the new sally-port on N. W. face, to cover the casement-arches on that face with concrete and mastic, to construct service-magazine for guns 1, 2, and 3, and fill in adjacent traverses, to hang all the service-magazine doors, repair cisterns, making pipe-connections therewith, and lay some additional gun-platforms. Platforms 1, 2, and 3 are yet to be laid, and those at positions 9 and 10 require to be replaced by platforms for large guns, before the work is in readiness for all of its approved armament.

Fort Johnson, Charleston Harbor, South Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—No operations were carried on at this work during the past fiscal year. Four mortar-platforms were purchased from the contingent fund for fortifications, but they were not laid. The approved projects for reconstructing and modifying this old work contemplates making of it a battery for four mortars and four guns, with the necessary parapets, traverses, and magazines.

No appropriation was made for the fiscal year ending June 30, 1875.
No appropriation asked for next fiscal year.

Castle Pinckney, Charleston Harbor, South Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—No operations have been carried on at this work during the past fiscal year, and there are no available funds at the present time. An appropriation is needed to fit it for the reception of 10-inch smooth-bores or corresponding rifles to be mounted *en barbette*.

No appropriation was made for the fiscal year ending June 30, 1875.
No appropriation asked for next fiscal year.

Fort Jackson, Savannah River, Georgia, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—During the past fiscal year the parapet and breast-height wall of the work have been finished, the parade-wall has been raised to its proper height and concrete foundations for guns 1, 2, 4, and 5 built, and the gun-platforms laid thereon. Platforms 2, 3, 4, and 5 are for the approved armament, temporarily adapted to smaller calibers. Platform 1 (constructed at the work) is for a 10-inch gun. A temporary armament of five guns has been mounted, 10-inch smooth-

bore in positions 1, 2, and 3, and one hundred pounder Parrott rifles in positions 4 and 5.

No appropriation was made for the fiscal year ending June 30, 1875.

Appropriation asked for next fiscal year..... \$7,700

Fort Pulaski, mouth of Savannah River, Georgia, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—The work has been confined to the demi-lune. During the past fiscal year there have been finished the breast-height wall and concrete foundations of gun-platforms 8 and 9; the masonry of service-magazine and passage-way between guns 7 and 8; the masonry of breast-height wall, foundation retaining-wall, the sand filling and concrete foundation for guns 6 and 7; the piling and masonry for service-magazine between guns 5 and 6; the piling, breast-height wall, and sand and concrete foundation for gun-platform No. 5; the piling, masonry of breast-height wall, foundation retaining-wall, and sand and concrete foundation for gun-platforms 3 and 4; the piling and masonry of service-magazine between 3 and 4; the excavation for foundation of storage-magazine, and the parapet for guns 8 and 9. For guns 6 and 7 the parapet is about three-fourths finished, and the parados in rear of 8 and 9 is roughly formed. Center-pintle platform No. 5, and front-pintle platforms Nos. 3, 4, 6, 7, 8, and 9, (all timber platforms,) have been laid, and two guns of the approved caliber mounted on 8 and 9. No more gun-platforms are to be laid in the demi-lune. In the water-battery, west of the north wharf, a new breast-height of timber has been put up and the parapet and traverses repaired.

Amount appropriated for the fiscal year ending June 30, 1875..... \$20,000

Appropriation asked for next fiscal year..... 50,000

During the present fiscal year it is proposed to confine the work to the demi-lune, in constructing the storage-magazine, and the retaining-wall west of demi-lune sally-port, in hanging all the magazine-doors, and in continuing sand-filling and sodding of slopes.

New Fort on Tybee Island, mouth of Savannah River, Georgia, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—The plans for defensive works on the north point of Tybee Island are still under consideration. The land required by the United States has been surveyed, but has not yet been purchased, for the reason that the parties claiming to own it, and who made an offer to sell, which was subsequently accepted, have been unable as yet to show any title.

No appropriation for the work has yet been made.

No appropriation asked for next fiscal year.

Fort Clinch, Amelia Island, Florida, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—No operations have been carried on at this work during the past fiscal year, and there are no funds available at the present time, except the balance of a small sum allotted for hiring a fort-keeper, from the appropriation for contingencies of fortifications. The modification of this work is still under consideration.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Fort Marion, St. Augustine, Florida, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—No operations have been carried on at this work during the last and none contemplated during the present fiscal year.

No appropriation asked for.

Fort Taylor and Batteries, Key West, Florida, in charge of Lieut. Col. C. E. Blunt, Corps of Engineers, until January 29, 1874; since that date in

charge of Maj. Jared A. Smith, Corps of Engineers.—During the past fiscal year the foundations of sea-faces of scarp-wall for south battery have been excavated to the coral rock and filled with concrete complete. The scarp or sea-wall on face running east has been completed 352 feet from angle, and the remaining portion finished save coping. On face running northwest the wall is completed 196 feet from angle, and an additional distance of 165 feet finished, save coping. About one-half the sand required to complete embankment and parapet on the easterly face of battery has been procured and placed in position. Although looking to emplacements for guns as an ultimate result, none have been finished during the year. The extensive damages caused by the hurricane, October 6, 1873, to buildings, railroad, and other portions of the work, have been thoroughly repaired. A new locomotive has been purchased, most of the freight-cars have been rebuilt, and much other work done to facilitate future operations.

Amount appropriated for the fiscal year ending June 30, 1875	\$20,000
Appropriation asked for next fiscal year	50,000

During the present fiscal year operations will be confined principally to completing the scarp-wall and collecting sand for parapet, &c., of south battery.

Fort Jefferson, Garden Key, Tortugas, Florida, in charge of Lieut. Col. C. E. Blunt, Corps of Engineers, until January 29, 1874; since that date in charge of Maj. Jared A. Smith Corps of Engineers.—A considerable part of the work during the past fiscal year consisted in repairing damages caused by a destructive hurricane in October, 1873. These damages have been completely repaired; the officers' quarters partially, and soldiers' barracks entirely roofed with galvanized iron, and the work in both these buildings brought comparatively near completion. A large quantity of sand has been collected and the embankments and roofing of traverse-magazines somewhat more than half completed. Five of the barbette-gun platforms have been fitted with 4-inch pintles for 10-inch Rodman guns, and the pintles procured and arrangements made for setting them in the eight remaining platforms. Considerable work has been done to put the temporary buildings, sewers, and other parts of the work in thorough order.

No appropriation was made for the fiscal year ending June 30, 1875.	
Appropriation asked for next fiscal year	\$50,000

Fort Pickens, Pensacola Harbor, Florida, in charge of Capt. A. N. Darnell, Corps of Engineers.—During the past fiscal year the cistern in the S. W. bastion, two outer and six inner magazine-doors, two postern-doors, store-houses, quarters, and kitchen for workmen, were repaired; four 4-inch front-pintle masonry platforms with low traverse-stones, and two of same with high traverse-stones, were constructed for ordnance on hand; two of same with low traverse-stones were nearly completed. Thirty-three 4-inch pintle masonry platforms were taken up, preparatory to constructing front-pintle platforms for ordnance on hand. Fifty wooden embrasure-shutters for the casemates were made and put up.

The old unserviceable railroad-track was taken up, and lumber purchased and sent there to rebuild it.

No appropriation was made for the fiscal year ending June 30, 1875.	
Appropriation asked for next fiscal year	\$50,000

During the next fiscal year it is proposed to commence some of the new exterior works, which have been approved, for the modification of this work.

Fort Barrancas and Redoubt, Pensacola Harbor, Florida, in charge of Capt. A. N. Damrell, Corps of Engineers.—During the past fiscal year preparations for constructing four 4-inch front-pintle platforms for two 100-pounder and two 200-pounder Parrott rifles were made, and the necessary material sent there.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Fort McRee, Pensacola Harbor, Florida, in charge of Capt. A. N. Damrell, Corps of Engineers.—The site of this work has been undermined by the action of the sea to such an extent, that much of its scarp has fallen down, leaving the casemates open, and it is generally in so dilapidated a condition as to be beyond repair, and to possess no value beyond the materials of which it is composed.

Projects have been prepared by the board of engineers for fortifications, and approved, for the erection of barbette-batteries for heavy guns, and a mortar-battery, to take the place of the old work, in rear of the present site, and upon ground beyond the encroachments of the sea, for which an appropriation of \$50,000 is asked for the next fiscal year to commence the work of construction.

Fort Morgan, eastern entrance to Mobile Bay, Alabama, in charge of Capt. A. N. Damrell, Corps of Engineers.—During the past fiscal year the sea-wall for the protection of the western or channel front of the fort was completed; thirty-one running feet of the old drain were rebuilt; the gate at the main entrance was repaired, the grass on the slopes and in the ditch was cut, and the weeds removed; ten 4-inch front-pintle masonry platforms, with low traverse-stones, and two of same with high traverse-stones, were constructed for ordnance on hand.

No appropriation was made for the fiscal year ending June 30, 1875.

Appropriation asked for next fiscal year..... \$50,000

During the present fiscal year it is proposed to maintain a watch over engineer property, and to make such slight repairs as may become necessary.

A plan has been prepared for the modification of this work by the construction of exterior batteries, with positions for thirty-seven guns of the largest caliber, and by arranging emplacements for mortars in the old work, at a total cost of \$370,000.

Fort Gaines, Dauphin Island, Mobile Bay, Alabama, in charge of Capt. A. N. Damrell, Corps of Engineers.—During the past fiscal year four palmetto pile-jetties, for the preservation of the shore and glacis on the eastern front of the fort, were completed; four front and four center pintle platforms were taken up preparatory to constructing 4-inch front-pintle platforms for ordnance on hand; four gun-carriages and chassis were removed from the beach to the fort; some slight repairs were made to the engineer buildings, and the same whitewashed.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

A plan has been prepared for the modification of this work, adapting it to the use of more powerful artillery, the estimated cost of which is \$83,000.

Fort on Ship Island, coast of Mississippi, in charge of Capt. A. N. Damrell, Corps of Engineers.—During the past fiscal year a temporary bridge was erected across the drawbridge-well, so that ordnance could be transported into the fort. Two 15-inch Rodman guns and two 100-pounder Parrott guns were mounted by the Ordnance Department.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Fort Pike, Rigolets Pass, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This work commands the passage by vessels drawing 7 feet or less through the Rigolets into Lake Pontchartrain, and to the wharves on the lake-front of New Orleans. Projects for its modification, in accordance with the approved system, were approved in 1870, and detailed estimates of the cost of the proposed modification made out.

During the past fiscal year operations have been confined to necessary repairs for the preservation of the work.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Fort Macomb, Chef Menteur Pass, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This work commands the passage by vessels drawing $4\frac{1}{2}$ feet or less through the Bayou Chef Menteur into Lake Pontchartrain, and the road along Gentilly Ridge to the city of New Orleans. Projects for the modification of this work, to fit it for the reception of the latest approved armament, were submitted in 1870, and estimates of cost prepared. During the past fiscal year operations have been limited to repairs necessary for the preservation of the work.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Tower Duprés, Lake Borgne, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—During the past fiscal year repair of the tower was completed and a keeper put in charge to prevent further damage by malicious persons.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Battery Bienvenue, Lake Borgne, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—No work was done during the past fiscal year, except for the care and preservation of the battery and building pertaining to it. A fort-keeper was retained in charge.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Tower at Proctorsville, Lake Borgne, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—No work done during the past fiscal year.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Fort Jackson, Mississippi River, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This work, and Fort St. Philip, nearly opposite, sixty-five miles below New Orleans, constitute the main defenses of that city against hostile naval expeditions. The depth of water through the bayous and lakes leading toward the city will only permit the approach of the smaller vessels carrying light armaments. The principal channel-way to the city, through which a naval attack may be made, is the Mississippi River.

Operations during the past fiscal year consisted in improving the drainage of the site of the fort; regrading and grassing new earth-work; keeping the slopes of old earth-work in good condition; providing twenty wooden platforms for fifteen-inch guns; laying four foundations for platforms; providing material for sixteen foundations; providing iron for three iron bridges across moats; constructing concrete piers for these bridges; providing means of transportation between New Orleans and the forts.

Amount appropriated for the fiscal year ending June 30, 1875.....	\$30,000
Appropriation asked for next fiscal year.....	42,000

During the present fiscal year it is proposed to put in position as many platforms for guns as possible, with the appropriation available, after putting up superstructure of bridges, making repairs to levees, and providing for care of the work during the year.

Fort St. Philip, Mississippi River, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—Operations during the past fiscal year consisted in the construction of three magazine-traverses; the partial construction of two others; the completion of the parapet and temporary breast-height wall of the lower battery; grading and sodding the slopes of the upper battery; the demolition of two old magazines and the redan on north front of main work; the preparation of the material obtained for use; the reclamation of earth for future use from the batture in front of the fort; providing eighteen wooden platforms for fifteen-inch guns; laying two foundations for platforms; providing material for sixteen foundations and for completing magazine-traverses; providing adequate means of transportation between New Orleans and the forts.

Amount appropriated for the fiscal year ending June 30, 1875.....	\$30,000
Appropriation asked for next fiscal year.....	46,000

During the present fiscal year it is proposed to complete two magazines in upper battery, place eighteen gun-platforms in position, and care for the work.

Fort Livingston, Barataria Bay, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This barrette work is situated on the western end of Grand Terre Island, at the entrance to Barataria Bay. It guards the only approach to New Orleans by vessels drawing seven feet or less, available on the west side of the Mississippi River. It also secures a safe anchorage and harbor of refuge for our own light-draught coasters in time of war. A project for its modification and repair was devised and approved in 1870. To carry to completion this approved project there will be required an appropriation of \$58,000.

During the past fiscal year no operations have been carried on except for the care and preservation of the work.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Fort at Fort Point, entrance to San Francisco Harbor, California, in charge of Lieut. Col. C. S. Stewart, Corps of Engineers.—During the past fiscal year four service-magazines have been built—one completed from height of two feet ten inches above its floor, three nearly half finished, a concrete foundation for eight platforms for heavy guns and for the corresponding breast-height walls put down to the level of beds of pindle-blocks, making in all 2,025 cubic yards of masonry. Pinfles and rails have been placed on two platforms for fifteen-inch guns, and four platforms for heavy mortars constructed. The embankment of the right of the inner line of batteries has been completed to the height originally designed, and for 690 running feet of parapets of extension of the outer line the earth-work is nearly half in place; in all, some 21,194 cubic yards. About 8,100 square yards of sodding have been put in place on slopes. Asphaltic flooring has been placed in eleven traverse-magazines. The wharf has been rebuilt, and much miscellaneous work done.

Amount appropriated for the fiscal year ending June 30, 1875.....	\$30,000
Appropriation asked for next fiscal year.....	50,000

Fort at Lime Point, San Francisco Harbor, California, in charge of Maj. George H. Mendell, Corps of Engineers.—During the past fiscal year

1,228 cubic yards of masonry were put in place; 55,717 cubic yards of excavation were made; 7,980 square yards of soil were hauled from a distance for parapets and magazine-coverings; 7,480 square yards of sod-dings were laid on the parapets and traverses. The battery at Point Cavallo was completed with the exception of gun-platforms and breast-height walls. The parapets and traverses in the Gravelly Beach Battery, having yielded under the winter-storms, they were filled with soil to the proper level and partially sodded. The road to the new site near Point Diablo was commenced, and 4,200 lineal feet completed. The masonry-work at Point Cavallo was put upon two magazines and on the necessary drains.

Amount appropriated for the fiscal year ending June 30, 1875.....	\$30,000
Appropriation asked for next fiscal year.....	50,000

During the present fiscal year it is proposed to complete the road begun, to build the advance battery at Point Cavallo, and to execute such work at Point Diablo as proves practicable.

Fort on Alcatraz Island, San Francisco Harbor, California, in charge of Maj. George H. Mendell, Corps of Engineers.—During the past fiscal year 1,185 cubic yards of masonry were put in place, and 59,160 cubic yards of excavation and filling were made. The south caponnière was partially remodeled. Two magazines, with bomb-proofs, were built. The breast-height walls for two guns were built and two stone platforms laid. Parapets for four guns were made; 6,300 square yards of sod-ding were laid on parapets, magazines, and slopes. The timber-work on the greater part of the old wharf was renewed. The wood revetment in rear of the wharf was replaced by a substantial stone wall laid in mortar. The retaining-wall in battery 1 was extended thirty-five feet.

Amount appropriated for the fiscal year ending June 30, 1875.....	\$20,000
Appropriation asked for next fiscal year.....	50,000

During the present fiscal year the south caponnière and shell-room will be completed. Magazines R and S will be covered and sodded. The filling in battery 7 will probably be completed, and the excavations on the south end of the island will be completed.

Batteries at Point San José, San Francisco Harbor, California, in charge of Lieut. Col. C. S. Stewart, Corps of Engineers.—*East Battery.*—The six wooden front-pintle platforms are rotten and unserviceable. The timbers of the magazine are so rotten that it has not been used for years.

West Battery.—The three platforms on the left are serviceable, the three on the right unserviceable from decay of timber. The timber of the magazine has not yet fallen in. No work has been done during the past fiscal year and none contemplated during the present year.

No appropriation was made for the fiscal year ending June 30, 1875.
No appropriation asked for next fiscal year.

Batteries on Angel Island, San Francisco Harbor, California, in charge of Lieut. Col. C. S. Stewart, Corps of Engineers.—These three temporary earth-works, constructed during the late war, are essentially unserviceable. The platforms are decayed, and most of the carriages have been condemned. It is proposed to postpone the commencement of batteries of a permanent character, projected to replace them, until more advanced points are fortified.

No appropriation was made for the fiscal year ending June 30, 1875.
No appropriation asked for next fiscal year.

Fort at San Diego, California, in charge of Lieut. Col. C. S. Stewart, Corps of Engineers.—During the past fiscal year work has been directed chiefly to the completion of buildings and the construction of embankments.

The stable, 24 by 50 feet, has been finished, and a stone house, 24 by 50 feet, a carpenter's shop, 14 by 24 feet, and overseer's quarters, 24 by 34 feet, built. The site has been cleared, and 27,626 cubic yards of embankment made along the right and left faces, and in the parade to about reference (20.00). Concrete drains have been built for a length of 380 feet, and the foundations of one magazine laid, and its walls carried up to the spring of main arch, requiring 313 cubic yards of concrete.

No appropriation was made for the fiscal year ending June 30, 1875.

No appropriation asked for next fiscal year.

Defenses of the mouth of the Columbia River, Oregon, in charge of Maj. Henry M. Robert, Corps of Engineers, from July 1, 1873, to October 22, 1873; since that date in charge of Maj. N. Michler, Corps of Engineers.—These defenses consist of Fort Stevens, on the south side, and three detached batteries at Cape Disappointment, Washington Territory, on the north side of the entrance. The works are in a very dilapidated condition, the entire wood-work of Fort Stevens, except the magazine, which is sadly in need of repair, being rotten. The wooden revetment of the interior slopes all around the fort is fallen, and several traverses lying in a confused mass of earth and timber; the sea threatens the site of the fort. All the magazines at Cape Disappointment are in such a dilapidated condition as to be useless.

No appropriation was made for the fiscal year ending June 30, 1875.

Appropriation asked for next fiscal year..... \$20,000

During the past fiscal year the operations were confined to making the annual survey of Sand Island and Point Adams.

BOARDS OF ENGINEERS.

The board of engineers for fortifications, stationed in New York City, consisting of Col. J. G. Barnard, Col. Geo. W. Cullum, (until January 13, 1874,) Lieut. Col. Z. B. Tower, and Lieut. Col. H. G. Wright, and, for the time being, the officer in charge of the defenses under consideration, has submitted during the past fiscal year reports upon applications of the Treasury Department for transfer of a portion of Presidio reservation, known as Mountain Lake, for the erection of a marine hospital, and for permission to build a road through Fort Stevens military reservation, Oregon, from the fort to the site of light-house; in reference to manner of finishing traverses and breast-height walls of batteries, showing a method of securing thicker and higher traverse and greater security to gunners serving the piece; upon project of Capt. C. W. Howell, substituting for the proposed battery above Fort Jackson, La., a battery of like number of guns on the Fort St. Philip side of the river and below that work; upon project of Maj. Wm. P. Craighill for changing the advanced casemate battery of Fort Monroe into a barbette-battery; upon the subject of the introduction of the Gatling gun into our service for flank-defense of fortifications; upon question of expediency of using concrete in breast-height walls in northern climates; upon House resolution of February 16, 1874, relative to the sale of Horn Island military reservation, Gulf of Mexico; upon application of Mr. John V. Cockroft to purchase or hire the property at St. Augustine, Fla., known as Fort Marion; upon proposed plan for mortar-battery at Fort Johnson, S. C.; upon proposed modification of Fort Pickens, and plans for construction of batteries exterior to that work; also on opposite side of channel, near Forts McRee and Barrancas; upon subject of defense of harbors of New York and Philadelphia by torpedoes, the manner of leading cables to shore, and construction of operating-rooms, &c.,

and a preliminary report on project for the modification of Fort Pickens and other works of defense in Pensacola Harbor. It has likewise submitted reports on the purchase of land on northern extremity of Tybee Island, Ga.; on the establishment of batteries for defense of Tybee Roads; on the construction of additional casemates to the rear of bar-bette-battery at Willet's Point; for storage of torpedo-cables, &c.; on the purchase of Cow Island and portions of Great Hog Island, Casco Bay, Me.; on establishment of batteries to command the Hussey Sound entrance to Portland Harbor, Me., and to control the inner anchorage to the northeast; on the constructions of breast-height walls, recommending that the masonry steps be omitted, and on the taking down of experimental targets at Fort Monroe and utilizing the material in other works.

The board has likewise reported upon the question of a project involving the use of iron or its equivalent in the scarps of casemated works; upon proposed change, suggested by the Ordnance Department, in lengthening the 12-inch rifle and 15-inch smooth-bore guns; and has examined and reported upon projects for various objects, among them Major Baylor's design for an iron platform for 13-inch sea-coast mortars, Mr. Ed. Brady's project for construction of iron turrets, and Mr. Robt. C. Totten's design for an experimental target of chilled and cast iron. It has also submitted a project for the expenditure of appropriation of \$125,000 for torpedoes for harbor defense.

Besides the subjects reported upon, the board has been engaged in the consideration of defenses for the entrance of Cape Fear River, N. C., defenses for Tybee Island, entrance to Savannah River, Ga., modification of Fort Clinch and batteries at New Bedford and New London, which questions are still before it and for most of which plans are now in progress.

TORPEDO-DEFENSE.

During the first three months of the year, Maj. H. L. Abbot, Corps of Engineers, the member of the board of engineers in immediate charge of the subject of the trials of torpedoes for harbor-defense, was absent in Europe on torpedo-duty, and the trials at Willet's Point were suspended. Since his return they have been actively prosecuted, and much has been accomplished in the way of preparing for the practical application of the system to the defenses of our harbors.

The electrical laboratory has received suitable additions, and the building has been extended to comprise a model operating-room, in which are placed all the parts of our own system, in their proper relations, for easy study.

The whole material of the service has received careful study, with the following results: Satisfactory forms of buoyant and ground torpedoes, with their buoys, have been provisionally adopted. They are designed to be planted at — feet intervals, and are harmless to each other at that distance with proper charges of dynamite; neither does the explosion close the circuit-closers of neighboring mines.

After much experimental study, the circuit-closer has been perfected. Its cost is trifling, and it seems to fulfill all requisite conditions. In the investigation a plan was devised which enabled all the various patterns to be accurately compared with each other, by making them print an electrical record of their action under a concussion closely assimilated to that of a vessel, but which could be repeated at will under identical circumstances.

In order to make it more convenient to vary the number of mines at

different stations, a box-form of operating-apparatus, adapted to seven cables, has been perfected. It works admirably.

The discovery made last year, that induction in neighboring cables, occasioned by electricity of high tension, could be overcome by a simple device, has been confirmed and extended to the multiple cables, and an improved form of apparatus for judgment-firing has been perfected.

Tests of cable imported two years ago, and stored in light sheds exposed to variations of temperature, have been carefully made and shown to have experienced no deterioration.

A device by which the tampering with a mine or its cable can be made to discharge a volley of guns previously pointed along the line, has been perfected. Its value in the night, or in fogs, is apparent, especially as the explosion is effected without exploding the torpedo itself.

As heretofore, much time has been devoted to fuse-testing, and after a strict comparison of those to be had abroad or in this country with our own, the result is all that can be desired. There are none better, and but few so good as our own. This investigation has included cut-offs as well as platinum and tension fuses.

After careful trials, extending over many months, a form of Le Clanche battery has been adopted for both signal and firing batteries. Other forms could be used if necessary, but it seems to combine every requisite for a good service-pattern.

The possession of an admirable collection of instruments in the laboratory, has enabled the co-efficients of the galvanometers, stored for torpedo-service, to be accurately determined, and thus the different stations will be able to refer all results to a uniform standard, an advantage of no slight importance. The tests of cables, joints, &c., have been rendered easy and accurate by the construction of a 1,000-cell sal-ammoniac battery, by the engineer troops, and a standard Clark battery by the officers.

Trials with explosives have been continued, but not so extensively as heretofore. Rendrock is the only new one added to the list, and it has shown itself inferior to dynamite. An old barge, worn out in service, was blown up last autumn, but it was too rotten to afford data of value.

Considering that the subject of torpedo-defenses has been sufficiently discussed to justify detailed plans for applying these new engines to the closing of our more important harbors, the board of engineers has taken up that subject for careful study. Projects for adapting the forts in the harbors of New York and Philadelphia to receive the cables, electrical apparatus, &c., have been already submitted, with diagrams of the proposed lines of torpedoes, and detailed drawings of the latter are in progress. Other harbors will be considered in turn.

Another very important investigation has been that reported upon on the manner of leading cables from the forts to deep water, accompanied by model-plans, &c.

The board expresses the opinion that our torpedo-system is satisfactory, and that moderate stores for applying it should be collected at the depot at Willet's Point. These stores should be increased for the present by large annual appropriations, as it is certain that no money devoted to fortifications is more directly applied to preparing for sudden defense. In this connection it must be understood that trained soldiers are absolutely necessary in using the mines, and that the number of enlisted men of engineers now authorized is entirely insufficient. At least three times as many will be needed for protecting even a few of our more important harbors.

The experimental target for determining the action of torpedoes on

the double bottoms of iron-clads is completed, and in readiness for the tests to which it will soon be subjected.

An appropriation of \$150,000 is respectfully recommended for the next fiscal year, to be expended in the purchase of such parts of the torpedo-apparatus and material as cannot be suddenly obtained in case of need.

The board of engineers for the Pacific coast, consisting of Lieut. Col. B. S. Alexander, Lieut. Col. C. S. Stewart, and Maj. Geo. H. Mendell, has been engaged during the past fiscal year in completing the project for field-works for the protection of the rear of the permanent sea-coast defenses at Fort Point, in maturing details for the permanent defensive works at Fort Point, at Lime Point, and at Alcatraz Island, and in the examination of San Diego Harbor, for the purpose of ascertaining the amount of sediment brought into this harbor by floods in the San Diego River.

The board has also reported on the question of water-supply and roads in case a marine hospital be erected on the shores of Mountain Lake; on the necessity of San Clemente Island for purposes of defense; and on the application of the Light-House Board to place a fog-signal on Yerba Buena Island.

In addition to the regular duties of the board of engineers for the Pacific coast, the members of the board have given a great part of their time during the year to the study of other subjects; to making an examination of the Sacramento, San Joaquin, and Tulare Valleys, in California, and making a report on the irrigation of these valleys; and to making an examination and report on the improvement of the harbor of Oakland, San Francisco Bay.

BATTALION OF ENGINEERS AND ENGINEER DEPOTS.

Battalion of Engineers, commanded by Maj. Henry L. Abbott, Corps of Engineers, headquarters Willet's Point, eastern entrance to New York Harbor.

The strength of the five companies of sappers, miners, and pontoniers, constituting the Battalion of Engineers, on the 30th of June, 1874, was 10 officers and 318 enlisted men, 36 recruits being needed to complete the organization, as determined by General Orders No. 122, series of 1870, from the War Department.

The companies of the battalion were stationed and commanded as follows: At Willet's Point, Company A, Second Lieut. William T. Rosell; Company B, Capt. W. R. King; Company C, Capt. William R. Livermore; Company D, (a skeleton organization,) under command of the battalion adjutant, First Lieut. James Mercur.

At West Point, Company E, Capt. O. H. Ernst, also instructor of practical engineering and *ex-officio* member of the academic board.

During the year, and for limited periods, detachments from the battalion served as follows: One sergeant and 5 first-class privates at Jefferson Barracks, Mo., guarding and caring for the engineer property there. This detachment left Jefferson Barracks and returned to the battalion July 15, 1873. At headquarters Department of Missouri, 2 sergeants and 5 first-class privates; at headquarters Department of Dakota, 2 sergeants and 5 first-class privates; on field-duty under First Lieut. George M. Wheeler, in Utah, Colorado, and Wyoming Territories, 1 first-class and 5 second-class privates.

Recruiting for the battalion has been carried on during the past year on the same system as during the preceding; but one rendezvous, how-

ever, that in New York City, having been kept open. During the year 96 men were enlisted, 9 re-enlisted, 47 deserters were apprehended, and 57 men deserted.

The duties of the battalion generally have been confined to guarding, receiving, and issuing the engineer-property at the depots; in furnishing instruction to cadets of the Military Academy, under the instructor of practical engineering; in pontoniering, signaling, telegraphing, and practical engineering generally; the detachments serving at the several headquarters in the field assisting the engineer-officers in the duties assigned them.

At Willet's Point the troops have been employed in the construction and repair of the buildings and grading the grounds, and in the various drills and instructions necessary to keep them in a proper state of efficiency and ready for active service. Good progress has been made in field-fortification, pontoniering, military reconnoissance, photography, and infantry tactics, while, in addition to the usual target practice furnished by regulations, the men have been encouraged to compete at the neighboring *range*. Theoretical instruction of the non-commissioned officers was had during the suspension of the drills in the winter, and the school of enlisted men, directed by General Orders No. 56, Adjutant-General's Office, 1866, was open to voluntary attendance, under the personal supervision of the commissioned officers.

The instruction of the officers has been extended, so as to include as far as practicable preparation for and familiarity with duties upon which they are liable to be ordered. By the authority of the Secretary of War each officer was, during the winter, required to visit and report upon some specified public work, selected with a view to obtaining information useful for the engineer service. These reports are of a creditable character, and will be used by the officers when examined for promotion.

The work of the torpedo-school has been actively prosecuted, and the results obtained are of a satisfactory character. The investigations necessary to discover the laws which govern the action of subaqueous explosions, the perfecting of the electrical apparatus, and the trials designed to determine the practical details of the mines, cables, fuses, &c., have all received careful attention. A system, believed to be superior to any in use abroad, has thus been perfected. To render it available in harbor defense, a body of trained officers and men is essential, and the instruction of the Battalion of Engineers has been specially directed to this end. The preparation of a torpedo manual has been commenced, and it is tested page by page by practical use as it proceeds.

In torpedo-materials we have collected about six hundred miles of cable, some three hundred mines, and electrical apparatus sufficient to equip some twenty stations; in fine, great progress has been made during the past year in reducing the theoretical system to a practical form for actual use. To make use of our materials, however, a trained body of men must be at hand and ready upon any emergency for the several torpedo-stations, but to this end the strength of the Engineer Battalion should be increased.

I would respectfully recommend an appropriation of \$1,000 for the purchase of engineer-material to continue the present system of instruction of the battalion, and \$10,000 for continuing the trials with torpedoes, and for the instruction of the engineer troops in their application to harbor and land defenses.

I would also renew my recommendation of former years, that the organization of the battalion be completed by the addition of two principal musicians, allowed by law to troops of other arms.

Engineer post and depot at Willet's Point, New York Harbor, commanded by Maj. Henry L. Abbot, Corps of Engineers.

The engineer-depot at Willet's Point contains the ponton-trains, siege and mining tools, torpedo-materials, astronomical and surveying instruments, &c., pertaining to the engineer-service of the Army. It is garrisoned by a portion of the Engineer Battalion, which furnishes the needful guard, and issues the stores to officers of the corps upon requisition duly approved.

The public buildings are essentially completed, so that only a small appropriation of \$500 for repairs is needed.

For continuing the remodeling of the ponton-material to make it conform with the patterns adopted at the close of the late civil war an appropriation of \$1,000 is needed. Most of the labor will be supplied by the troops. Experience has shown that it is necessary, in order to avoid loss of time in fitting surveying-parties for the field, to have at the depot a small supply of the instruments in common demand. For this purpose, and for repairing those returned in an injured condition, an appropriation of \$5,000 is asked.

For incidental expenses of the depot, such as coal, forage, stationery, chemicals for use in the laboratory, extra-duty pay for soldiers employed in mechanical work, in photographic and lithographic plans, and in printing engineering blanks, torpedo-instructors, &c., \$2,500.

RIVER AND HARBOR IMPROVEMENT.

The "act making appropriations for the repair, preservation, and completion of certain public works on rivers and harbors," approved March 3, 1873, furnished the means for continuing, during the past year, operations at the several localities named therein, in accordance with approved projects. A brief account of the work done at each locality, and the present condition of the improvement, together with a money-statement, is given below; but for more detailed information a reference to the reports of the officers having charge and immediate supervision of the operations is respectfully suggested.

The annual estimates of the officers in charge of the separate works have been carefully revised in this office, and in many cases reduced.

The surveys and examinations directed to be made by the second section of the act, with but few exceptions, have been completed, and the results of those received in time were reported during the last session of Congress. These, together with such as have been completed since the adjournment, are submitted herewith in the appendix to this report.

The provisions of the third section of the act, requiring the organization of a board of engineer officers "whose duty it shall be to inquire into and report upon the practicability of bridging, consistently with the interests of navigation, the channel between Lake Huron and Lake Erie," &c., have been complied with, and the report of the board was submitted to the Department and transmitted by you to Congress on the 22d January. A copy of the report is appended hereto.

The river and harbor act approved June 23, 1874, in addition to making appropriations for continuing improvements heretofore begun, made provision for some new works. With the amounts thus made available operations have been continued during the present working season, and the necessary preliminary steps have been taken for the execution of the new work specified.

The act further directed that surveys be made and estimates submit-

ted for the improvements recommended by the Senate Select Committee on Transportation Routes to the Seaboard, upon the four routes indicated by the report of said committee, and also upon a route indicated, forming an extension of the Chesapeake and Ohio Canal. These surveys have been assigned to officers having charge of works in the districts through which the proposed routes of communication pass. The appropriation was allotted to these officers in proportion to the extent and magnitude of the survey assigned each. Parties were organized and sent into the field at as early a day as possible, and it is trusted that sufficient data will be obtained to enable all the officers to submit projects for the improvements recommended, together with approximate estimates of cost of each, in time to be submitted before the close of the next session of Congress. It should be borne in mind, however, that, owing to the lateness of the passage of the act, the season favorable for active field-work was well advanced before the parties could commence operations.

The examinations or surveys directed to be made at certain specified localities named in the second section of the act of June 23, 1874, are now in process of execution. It is expected that reports upon the greater portion of these will be received in time for transmission during the approaching session of Congress.

The third section of the act made provision for the organization of a board of engineers, and directed that "said board shall make a survey of the mouth of the Mississippi River, with a view to determine the best method of obtaining and maintaining a depth of water sufficient for the purposes of commerce, either by canal from said river to the waters of the Gulf, or by deepening one or more of the natural outlets of said river," &c. The board was constituted by General Orders No. 74 of the War Department, dated July 2, 1874, and a copy of the section was incorporated in the order for the information and guidance of the members. The board is now engaged in the prosecution of the duties assigned, and will doubtless be able to comply with the requirement of the law as to the time of submitting the report.

In accordance with the requirements of the act approved June 22, 1874, "to provide for the appointment of a commission of engineers to investigate and report a permanent plan for the reclamation of the alluvial basin of the Mississippi River subject to inundation," a board of commissioners was constituted by General Orders No. 73 of the War Department, of July 2, 1874. The board has been organized, and the members are now actively engaged in making the investigations necessary to a full understanding and a proper presentation of the matter under consideration.

In connection with this subject, I have thought it advisable to include in the present communication (Appendix M 4) a report on the levees of the Mississippi, made by me to the Secretary of War in May, 1866, in pursuance of his instructions.

LAKE HARBORS AND RIVERS.

HARBORS ON LAKE SUPERIOR WEST OF KEWEENAW POINT.

Officer in charge, Maj. F. U. Farquhar, Corps of Engineers.

1. *Improvement of the Bay of Superior from the natural entrance to the docks of Superior City and Du Luth, and preservation of both entrances from the lake thereto, Minnesota and Wisconsin.*—The work at these localities during the fiscal year comprised the completion of the piers at the Du

Luth Canal, and a small amount of dredging in Du Luth Harbor; the opening and protection of a cut through the dike across Superior Bay; the near completion of the piers at the natural entry, with some dredging between them, and the dredging of a channel from the deep waters of the bay to Quebec wharf, at Superior City.

The work during the fiscal year ending June 30, 1875, will be the completion of the piers at the natural entrance; some repairs to the piers at the Du Luth Canal, and dredging at the entrance to the harbor of Du Luth to give anchorage-ground and room for vessels to turn.

The completion of the plan for the improvement of the harbor of Du Luth, so that it may be available as a harbor of refuge, will require a large amount of dredging, which is estimated by the officer in charge at about 1,000,000 cubic yards, at the cost of about \$270,000. An estimate of \$100,000 is submitted for the commencement of this improvement.

The officer in charge recommends that the dike across Superior Bay be rebuilt so as to insure that no deterioration of the channel takes place at the natural entry. The estimated cost of this is \$87,199, which could be most economically expended if included in one appropriation.

A fund of \$10,000 should also be available for repairs at the natural entry.

Balance in the Treasury of the United States July 1, 1873.....	\$79,636 00
Amount in hands of officer and subject to his check.....	51,715 75
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	120,112 08
Amount available July 1, 1874.....	21,239 67
Amount required for the fiscal year ending { For Du Luth	100,000 00
June 30, 1876, (as revised in this Office,) { For natural entry	10,000 00

(See Appendix A 1.)

2. *Ontonagon Harbor, Michigan.*—With the amount appropriated by the act of June 23, 1874, it is proposed to repair the inner end of West pier and prolong it inward 430 feet, and to make other repairs to the structures now protecting the entrance to this harbor.

It is estimated by the officer in charge that the cost of completing the works for the improvement of this harbor will be \$238,717.08, and that \$150,000 can be economically expended during the year ending June 30, 1876.

This harbor would, were it properly improved, be of great importance as a harbor of refuge, as it is the only harbor on a long stretch of coast.

Balance in Treasury of the United States July 1, 1873.....	\$82 41
Amount appropriated by act approved June 23, 1874.....	23,000 00
Amount available July 1, 1874.....	23,082 41
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	50,000 00

(See Appendix A 2.)

3. *Eagle Harbor, Michigan.*—The estimate submitted in the last annual report for the excavation of a channel through the rock at the entrance to this harbor to a depth of 14 feet and a width of 130 feet, together with the building of a breakwater to cover the anchorage-ground, in all \$248,000, has been revised by the officer now in charge, and reduced to \$231,570, at the same time increasing the width of the breakwater from 20 feet to 30 feet.

No work has been done here during the past year, owing to the smallness of the funds on hand.

The officer in charge states that, should it be determined to make

this improvement, in order to prosecute it economically, a sum of at least \$150,000 should be appropriated for the fiscal year.

Balance in Treasury of the United States July 1, 1873.....	\$13,761 11
Amount in hands of officer and subject to his check.....	11,047 57
Amount expended during the fiscal year ending June 30, 1874.....	1,600 40
Amount available July 1, 1874.....	23,208 28
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	50,000 00

(See Appendix A 3.)

HARBORS ON LAKE SUPERIOR EAST OF KEWEENAW POINT AND HARBORS ON THE WEST AND SOUTH SHORES OF LAKE MICHIGAN—IMPROVEMENT OF THE FOX AND WISCONSIN RIVERS.

Officer in charge, Maj. D. C. Houston, Corps of Engineers, with Capt. J. W. Cuyler, Corps of Engineers, to March 11, 1874, and Capt. G. J. Lydecker, Corps of Engineers, since May 11, 1874, under his immediate orders.

1. *Marquette Harbor, Lake Superior, Michigan.*—During the year the breakwater, as far as completed, was entirely filled with stone ballast and covered with a decking of three-inch plank.

The superstructure was completed over 5 cribs sunk in 1872, and 1 crib has been sunk in extension of the breakwater. About 180 cords of stone has been placed as riprap on the exposed side of the work.

The length of the work, as it now stands, is 1,960 feet, all complete except the superstructure over two cribs. It is proposed this season to extend the breakwater 50 feet, and complete the superstructure over the two cribs placed last year.

To render this work secure, it should be still further protected on the seaward side by a stone riprapping, for which an estimate is submitted.

This will complete the breakwater as designed, at a cost of \$296,730, or \$88,399.58 less than the original estimate.

Balance in Treasury of United States July 1, 1873.....	\$15,000 00
Amount in hands of officer and subject to his check, (including percentage due on contracts not yet completed).....	\$2,373.83
Amount appropriated by act approved June 23, 1874.....	24,802 07
Amount expended during the fiscal year ending June 30, 1874.....	15,000 00
Amount available July 1, 1874.....	39,192 87
Amount required for the fiscal year ending June 30, 1876.....	15,609 20
	25,000 00

(See Appendix B 1.)

2. *Menomonee Harbor, Michigan and Wisconsin.*—During the year the south pier was extended 720 feet and the north pier 352 feet. During the present season it is proposed to extend each pier 128 feet and to dredge a channel 14 feet in depth and as wide as funds available will permit. The estimated cost of completing this harbor according to the plan adopted is \$212,000. There has been appropriated \$100,000.

The estimate submitted by the officer in charge for continuing this improvement is \$50,000.

Balance in Treasury of United States July 1, 1873.....	\$25,000 00
Amount in hands of officer and subject to his check, (including percentage due on contracts not yet completed).....	\$1,254.84
Amount appropriated by act approved June 23, 1874.....	11,350 01
Amount expended during the fiscal year ending June 30, 1874.....	25,000 00
Amount available July 1, 1874.....	34,837 69
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	26,512 32
	25,000 00

(See Appendix B 2.)

3. *Green Bay Harbor, Wisconsin.*—During the year the deepening and widening of the channel from the mouth of the Fox River to Grassy

Island was carried out as contemplated, the appropriation of \$20,000 in 1873 having been expended for this purpose.

The appropriation of this year, \$10,000, will be expended in continuing this work and in repairing the revetment to the cuts through Grassy Island.

The sum of \$45,000 is required to complete this channel, of which \$25,000 may be expended to advantage during the year ending June 30, 1876.

Balance in Treasury of United States July 1, 1873.....	\$10,000 00
Amount in hands of officer and subject to his check.....	9,726 00
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	19,662 38
Amount available July 1, 1874.....	10,063 62
Amount required for the fiscal year ending June 30, 1876.....	25,000 00

(See Appendix B 3.)

4. *Harbor of refuge at the entrance of the Sturgeon Bay Canal, Wisconsin.*—This work was commenced about the beginning of the fiscal year, an appropriation of \$40,000 having been made for it in 1873.

During the year two pile-piers were constructed, each 762 feet in length. The filling of the piers was not entirely completed.

The appropriation of 1874, \$10,000, will be expended in completing this filling and in extending each pier 32 feet, increasing the width of the pier from 14 to 18 feet.

The estimate submitted by the officer in charge for the further extension of these piers is \$60,000.

Balance in Treasury of United States July 1, 1873.....	\$20,000 00
Amount in hands of officer and subject to his check.....	19,936 00
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	37,980 55
Amount available July 1, 1874.....	11,955 45
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	40,000 00

(See Appendix B 4.)

5. *Ahnapee Harbor, Wisconsin.*—During the season of 1873, the balance of the appropriation for this harbor, made in 1872, since which time there has been no appropriation, was expended in extending the south pier 175 feet, making its total length 620 feet.

The north pier is 352 feet in length. The failure of the appropriation in 1873 left the work incomplete.

To make this harbor available for any purpose requires a channel to be dredged between the piers into the river.

The officer in charge submits an estimate, for continuing the improvement, of \$50,000.

Amount in hands of officer and subject to his check.....	\$9,380 11
Amount expended during the fiscal year ending June 30, 1874.....	8,926 06
Amount available July 1, 1874.....	454 05
Amount required for fiscal year ending June 30, 1876, (as revised in this Office).....	25,000 00

(See Appendix B 5.)

6. *Two Rivers Harbor, Wisconsin.*—During the past year the superstructure has been built over 1,031 feet of pile-foundation, and the piers filled with brush and stone, making the north pier 900 feet in length, and the south pier 965 feet. The dredge was employed in excavating a channel for vessels of light draught. During the present season the dredge will be employed in continuing the excavation. The piers will be refilled where the filling has settled, and the north side of the channel into the river revetted.

The appropriation of this year being but \$15,000, and it being proposed to expend a portion of this sum in using the dredge at Ahnapee Harbor, (the cost of the dredge having been paid for equally out of the appropriations for these two harbors,) it will not be practicable to extend the piers this season, though such extension is necessary to the maintenance of the channel.

An estimate is submitted by the officer in charge, for the extension of the piers and dredging, of \$50,000.

Balance in Treasury of United States July 1, 1873.....	\$25,000 00
Amount included in expenditures of year ending June 30, 1873, to be deducted from balance in Treasury.....	2,892 94
Amount appropriated by act approved June 23, 1874.....	15,000 00
Amount expended during the fiscal year ending June 30, 1874.....	22,055 70
Amount available July 1, 1874.....	15,051 36
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	25,000 00

(See Appendix B 6.)

7. *Manitowoc Harbor, Wisconsin.*—The work during the year has consisted in extending each pier 100 feet. It is proposed this season to make a further extension of 100 feet to each pier. A still further extension of 200 feet to each pier is necessary to carry them to a depth of 18 feet of water.

An estimate is submitted for a portion of this extension.

Balance in Treasury of United States July 1, 1873.....	\$20,000 00
Amount in hands of officer and subject to his check.....	3,635 02
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	13,794 24
Amount available July 1, 1874.....	19,840 78
Amount required for the fiscal year ending June 30, 1876.....	25,000 00

(See Appendix B 7.)

8. *Sheboygan Harbor, Wisconsin.*—During the year 288 feet of old superstructure have been removed and replaced by new work. These repairs will be continued, and the channel between the piers dredged out. The superstructure over the two cribs sunk in 1873 will also be built. The repairs of the old superstructure must be continued, and an estimate of \$12,000 is submitted for the purpose.

Balance in Treasury of United States July 1, 1873.....	\$10,000 00
Amount in hands of officer and subject to his check.....	17,506 89
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	21,496 09
Amount available July 1, 1874.....	16,010 80
Amount required for the fiscal year ending June 30, 1876.....	12,000 00

(See Appendix B 8.)

9. *Port Washington Harbor, Wisconsin.*—The work during the year has consisted in extending each pier 100 feet, and in dredging 14,000 yards of material between the piers and in the basin.

The present appropriation of \$10,000 will be applied to increasing the size of the basin and revetting its banks as fast as completed.

An estimate is submitted by the officer in charge, for continuing this improvement, of \$50,000.

Balance in Treasury of United States July 1, 1873.....	\$15,000 00
Amount in hands of officer and subject to his check.....	7,442 78
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	21,804 64
Amount available July 1, 1874.....	10,638 14
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	25,000 00

(See Appendix B 9.)

10. *Milwaukee Harbor, Wisconsin.*—During the year the sum of \$10,000 was applied to widening and deepening the channel between the piers, by dredging. The appropriation of this year, \$10,000, will be applied to the same purpose.

This harbor may be regarded as completed at present, so far as the extension of the piers is concerned. Periodical dredging will be required to maintain the channel, amounting to an average of \$5,000 per annum. It has become necessary, however, to replace the old superstructure built in 1856 and 1857, and it is recommended that this be done with stone masonry, as the cribs appear to have obtained a permanent settlement. The total estimated cost of replacing 2,240 feet of superstructure is about \$300,000, and an estimate for \$100,000 is submitted by the officer in charge for the next fiscal year.

Amount in hands of officer and subject to his check.....	\$10,000 00
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	9,568 73
Amount available July 1, 1874.....	10,431 27
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	50,000 00

(See Appendix B 10.)

11. *Racine Harbor, Wisconsin.*—During the year the north pier has been extended by sinking two cribs, 50 feet long by 30 feet wide, making an extension of 100 feet, and in dredging 16,773 cubic yards from the channel between the piers. It is proposed to expend the \$10,000 appropriation this year in placing one more crib in extension of this pier, and to build the superstructure over the two cribs placed last year. There will be required to complete this harbor for the present the completion of superstructure over the crib to be placed this season and dredging about 25,000 yards in the channel, for which an estimate is submitted.

Balance in Treasury of United States July 1, 1873.....	\$20,000 00
Amount included in expenditure of year ending June 30, 1873, to be deducted from balance in Treasury.....	88 00
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	19,520 40
Amount available July 1, 1874.....	10,391 60
Amount required for the fiscal year ending June 30, 1876.....	10,000 00

(See Appendix B 11.)

12. *Kenosha Harbor, Wisconsin.*—During the year the balance of the appropriation of 1872 was expended in building the superstructure over the crib sunk in extension of north pier in 1872. There being no appropriation in 1873 no other work was accomplished.

The sum of \$10,000, appropriated in 1874, will be applied to sinking one crib 50 feet long and 30 feet wide, in extension of the north pier, and in repairs, as far as possible, of damage caused to old work by the storms of last winter.

There is necessary to the further improvement of this harbor an additional extension of 50 feet to the north pier, superstructure over crib to be sunk this season, repairs to old work, and dredging in the channel, for all of which an estimate is submitted.

Amount in hands of officer and subject to his check.....	\$507 94
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	371 35
Amount available July 1, 1874.....	10,136 59
Amount required for the fiscal year ending June 30, 1876.....	30,000 00

(See Appendix B 12.)

13. *Chicago Harbor, Illinois.*—The work during the year consisted in extending the breakwater southward 1,150 feet, with the exception of

the superstructure, and in repairing slight damages caused by collisions and storms.

The work contemplated during the coming fiscal year is an extension of the breakwater 150 feet farther south and the completion of the superstructure over the entire work. This will nearly, if not quite, complete the breakwater.

It is proposed to defer the construction of the southern breakwater until it is determined whether wharves are to be built on the west side of the new harbor.

The work next proposed on the improvement of this harbor is the extension of the north pier 400 feet, for which an estimate is submitted.

Balance in Treasury of United States July 1, 1873.....	90,000 00
Amount in hands of officer and subject to his check, (including \$6,866.32, percentage due on contracts not yet completed).....	20,423 47
Amount appropriated by act approved June 23, 1874	75,000 00
Amount expended during the fiscal year ending June 30, 1874.....	107,198 23
Amount available July 1, 1874	78,225 24
Amount required for the fiscal year ending June 30, 1876	78,000 00

(See Appendix B 13.)

14. *Calumet Harbor, Illinois.*—The work during the fiscal year at this harbor consisted in extending the north and south piers each 200 feet, with the exception of the superstructure, and in building the superstructure over the cribs sunk in 1872.

37,465 cubic yards of sand were also removed from the channel between the piers.

At the close of operations in 1873 there was a dredged channel between the piers nearly 100 feet wide and 11 feet deep, in the shoalest place.

The appropriation of 1874, \$25,000, will be applied in further extension of the piers and in dredging.

An estimate is submitted for continuing this improvement :

Balance in Treasury of United States July 1, 1873.....	\$20,000 00
Amount in hands of officer and subject to his check.....	19,992 27
Amount appropriated by act approved June 23, 1874.....	25,000 00
Amount expended during the fiscal year ending June 30, 1874.....	39,273 05
Amount available July 1, 1874	25,719 22
Amount required for the fiscal year ending June 30, 1876	75,000 00

(See Appendix B 14.)

15. *Michigan City Harbor, Indiana.*—During the year the east pier of the outer harbor has been extended 503 feet, and the west pier extended out to the line of the proposed breakwater.

It is proposed this season to commence the construction of the breakwater proper with the appropriation of 1874.

An estimate is submitted for continuing this improvement.

Balance in Treasury of United States July 1, 1873	\$50,000 00
Amount in hands of officer and subject to his check, (including \$1,499.41 percentage due on contracts not yet completed).....	30,294 94
Amount appropriated by act approved June 23, 1874	50,000 00
Amount expended during the fiscal year ending June 30, 1874.....	78,241 93
Amount available July 1, 1874.....	52,053 01
Amount required for the fiscal year ending June 30, 1876	80,000 00

(See Appendix B 15.)

16. *New Buffalo Harbor, Michigan.*—No work has been done on this harbor, and none is proposed. There has been no appropriation made since 1872, and the amount available is too small to produce any benefit to commerce.

As mentioned in former reports, no estimate is submitted for this har-

bor, as it would be of no benefit to general commerce, and the local requirements are insignificant.

Balance in Treasury of United States July 1, 1873.....	\$5,000 00
Amount in hands of officer and subject to his check.....	4,211 15
Amount expended during the fiscal year ending June 30, 1874.....	1,131 00
Amount available July 1, 1874	8,080 15

17. *Improvement of the Fox and Wisconsin Rivers.*—The improvement of these rivers is being carried on in accordance with the plans heretofore reported, and the results are given in detail in the accompanying reports.

The work on the Fox River has been confined to the Lower Fox. It has consisted of repairs to the old locks and dams, more or less extensive according to their condition, and in deepening the levels so as to obtain the maximum draught of water. The old lower combined lock at Little Ohute, which was incapable of repairs, was torn out, and is in process of replacement by a permanent lock of stone masonry. This work is approaching completion. The old dam at Appleton was removed and is being replaced by a permanent dam of stone masonry, which will be finished this fall.

The completion of these two permanent works, the rebuilding of dam at Kaukauna and a few additional repairs to the old work, is all that is contemplated on the Lower Fox for the present.

On the Upper Fox nothing of importance, except surveys, was done during the year.

Work has been commenced under the appropriation of 1874, as follows, viz:

The construction of a new stone-masonry lock, near Eureka; the thorough repairs of Winnebago Lock; the deepening and revetting of the Portage Canal, and complete surveys of the Upper Fox.

On the Wisconsin River, the construction of wing-dams has progressed in accordance with the plan adopted for the improvement of the river, resulting, wherever the works have been completed, in obtaining an improved channel.

This work will be continued during the present working season.

Annual appropriations adequate to the magnitude of this work are earnestly recommended.

Balance in Treasury of United States July 1, 1873.....	\$200,000 00
Amount in hands of officer and subject to his check.....	27,837 13
Amount received from tolls for year ending June 30, 1873.....	1,893 27
Amount appropriated by act approved June 30, 1874.....	300,000 00
Amount expended during the fiscal year ending June 30, 1874.....	229,907 92
Amount available July 1, 1874	299,822 48
Amount required for the fiscal year ending June 30, 1876	750,000 00

(See Appendix B 16.)

HARBORS ON THE EASTERN SHORE OF LAKE MICHIGAN.

Officer in charge, Capt. (now Maj.) S. M. Mansfield, Corps of Engineers.

1. *Frankfort Harbor, Michigan.*—During the year the south pier has been extended 150 feet, (3 cribs.) During the coming season this pier will be further extended 50 feet, (1 crib,) the channel dredged throughout, and some necessary repairs put upon the old work.

Thirty-six thousand dollars will be required to complete the improvements.

Balance in Treasury of United States July 1, 1873.....	\$15,007 97
Deduct amount expended last fiscal year	441 46
Amount appropriated by act approved June 23, 1874	10,000 00

Amount expended during the fiscal year ending June 30, 1874.....	\$12, 178 89
Amount available July 1, 1874.....	12, 387 62
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	26, 000 00

(See Appendix C 1.)

2. *Manistee Harbor, Michigan.*—Three hundred and fifty feet of inside revetment have been built here, after cutting off a sharp bend in the river, on the south side.

During the next year 355 feet of revetment will be built on the north side, facing a sand-bank which is much exposed to wash to the detriment of the channel; also 140 feet of revetment on the south side in continuation of the work of last season.

To carry the piers into the lake to the depth of 16 feet water will require the extension of the north and south piers 650 and 750 feet, respectively, or the addition of 28 cribs, each 50 feet long; which, at \$4,000 each, will amount to \$112,000; of which sum \$50,000 can be profitably expended during the next fiscal year.

Balance in Treasury of United States July 1, 1873.....	\$15, 000 87
Deduct amount expended last fiscal year.....	3, 313 00
Amount appropriated by act approved June 23, 1874.....	10, 000 00
Amount expended during the fiscal year ending June 30, 1874.....	10, 945 74
Amount available July 1, 1874.....	10, 742 13
Amount required for the fiscal year ending June 30, 1876.....	50, 000 00

(See Appendix C 2.)

3. *Ludington Harbor, Michigan.*—Six 50-foot cribs were placed in extending south pier 300 feet. During the winter the outer crib lightened and rolled into the channel, leaving the pier extension 250 feet for the year's work.

During this season it is proposed to remove the old slab-revetment and sand-bank on the south side, revetting the face exposed; and to replace the crib mentioned above.

Ten thousand dollars is thought by the officer in charge to be necessary to dredge the channel and complete the improvements for some time to come.

Balance in Treasury of United States July 1, 1873.....	\$25, 000 00
Amount in hands of officer and subject to his check.....	3, 864 17
Amount appropriated by act approved June 23, 1874.....	20, 000 00
Amount expended during the fiscal year ending June 30, 1874.....	19, 414 68
Amount available July 1, 1874.....	27, 866 83
Amount required for the fiscal year ending June 30, 1876.....	10, 000 00

(See Appendix C 3.)

4. *Pentwater Harbor, Michigan.*—The top timbers and entire filling of the 300 feet of revetment left incomplete at date of last report have been finished. Two cribs (100 feet) were placed in extension of north pier, and the superstructure built over them. Some necessary repairs will also be made this season to the filling at several places in both piers.

No appropriation is asked.

Balance in Treasury of United States July 1, 1873.....	\$20, 000 00
Amount in hands of officer and subject to his check.....	10, 003 55
Amount expended during the fiscal year ending June 30, 1874.....	23, 639 51
Amount available July 1, 1874.....	6, 364 04

(See Appendix C 4.)

5. *White River Harbor, Michigan.*—During the last fiscal year the work at this harbor has been limited to making repairs, filling piers with brush, slabs, and stone ballast.

The present year the south pier will be extended 50 feet, (1 crib,) and slabs and stone will be added to the filling in the old work, while a portion of the appropriation will be held over for dredging the channel, should such contingency occur.

To carry out the south pier into 16½ feet water and the north pier into 11 feet, which is requisite to secure a permanent improvement, will cost \$44,525.60, to which should be added \$5,000 for dredging.

Balance in Treasury of United States July 1, 1873.....	\$7,003 53
Deduct amount expended last fiscal year.....	1,907 91
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	4,449 73
Amount available July 1, 1874.....	10,645 89
Amount required for the fiscal year ending June 30, 1876.....	49,500 00

(See Appendix C 5.)

6. *Muskegon Harbor, Michigan.*—No appropriation was made for this harbor last year.

The work under a former appropriation, 350 feet of revetment on south side and 250 feet on north side, was completed September 30, 1873.

With the \$10,000 appropriated by act of June 23, 1874, the south pier will be extended 50 feet, (1 crib,) and about 135 feet of pile-revetment will be added to the north side, eastward of the Government work, where the old slab-pier was burned and where a breach threatened.

Forty-six thousand dollars is asked to continue pier-extension, which the large commerce of this place demands.

Amount in hands of officer and subject to his check.....	\$9,778 40
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	9,698 43
Amount available July 1, 1874.....	10,079 97
Amount required for the fiscal year ending June 30, 1876.....	46,000 00

(See Appendix C 6.)

7. *Grand Haven Harbor, Michigan.*—Early in the past year some very needed repairs were put upon the south pier. Two thousand one hundred feet of pile-work for north pier and revetment was put under contract and nearly completed.

The present year the north pier will be extended 300 feet, (six cribs)—probably as far as it will need to go for some time to come—and 500 feet of pile-revetment will be constructed on the south side eastward of the former work.

The harbor is by far the best on this shore. It is 400 feet wide, with 20 feet of water.

No appropriation is required for the next fiscal year.

Balance in Treasury of United States July 1, 1873.....	\$75,000 00
Amount in hands of officer and subject to his check.....	6,305 76
Amount appropriated by act approved June 23, 1874.....	50,000 00
Amount expended during the fiscal year ending June 30, 1874.....	51,595 20
Amount available July 1, 1874.....	79,710 56

(See Appendix C 7.)

8. *Black Lake Harbor, Michigan.*—Four hundred feet of pile-revetment have been constructed on the south side during the year, and much of the filling of the old work renewed.

During the present season the piers will be extended, the south 100 feet and the north 50 feet, possibly 100 feet.

To secure permanency to the present good condition of this harbor, the piers should be extended to 15 feet of water, and \$35,000 is asked to continue this work of extension.

Balance in Treasury of United States July 1, 1873.....	\$12,007 35
Amount in hands of officer and subject to his check.....	1,042 38

Amount appropriated by act approved June 23, 1874.....	\$15,000 00
Amount expended during the fiscal year ending June 30, 1874.....	12,720 76
Amount available July 1, 1874.....	15,328 97
Amount required for the fiscal year ending June 30, 1876.....	35,000 00

(See Appendix C 8.)

9. *Saugatuck Harbor, Michigan.*—The contract made under the last appropriation was annulled for cause, and the work of building 400 feet of north pier is progressing by hired labor. It is about one-half completed. A wing-dam 243 feet long was built in the river to direct the current. It is proving of great benefit, apparently removing the agency which tended to undermine the revetment, and is depositing material where it is so much needed, and where the revetment has almost given way.

This year it is intended to build about 400 feet of pile-work, connecting the north pier with the shore.

Fifteen thousand dollars is asked to continue the improvements.

Balance in Treasury of United States July 1, 1873.....	\$20,000 00
Deduct amount expended last fiscal year	906 18
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	13,818 08
Amount available July 1, 1874	15,275 74
Amount required for the fiscal year ending June 30, 1876.....	15,000 00

(See Appendix C 9.)

10. *South Haven Harbor, Michigan.*—During the past year there were sunk in extension of the north pier two cribs, (50 feet each,) and in extension of the south pier one crib.

The coming season the superstructure will be completed, and about 300 feet of revetment on north side will be built.

To continue the improvement will require \$40,000.

Balance in Treasury of United States July 1, 1873.....	\$20,000 00
Amount in hands of officer and subject to his check.....	8,220 50
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	26,190 52
Amount available July 1, 1874.....	12,089 98
Amount required for the fiscal year ending June 30, 1876.....	40,000 00

(See Appendix C 10.)

11. *Saint Joseph Harbor, Michigan.*—No appropriation was made last year, and, beyond a survey made in June, nothing has been done during the year.

The appropriation of June 23, 1874, will be applied to the filling and ballasting of the present piers.

No appropriation is asked.

Amount in hands of officer and subject to his check.....	\$155 33
Amount appropriated by act approved June 23, 1874.....	2,000 00
Amount expended during the fiscal year ending June 30, 1874.....	34 76
Amount available July 1, 1874.....	2,120 57

(See Appendix C 11.)

ENLARGEMENT OF ST. MARY'S FALLS CANAL, AND IMPROVEMENT OF THE ST. MARY'S RIVER—HARBORS ON LAKES HURON AND ST. CLAIR—ST. CLAIR FLATS CANAL AND DETROIT RIVER.

Officer in charge, Maj. G. Weitzel, Corps of Engineers, with Capt. A. N. Lee, Corps of Engineers, under his immediate orders.

1. *St. Mary's Falls Canal.*—During the year the purchase of land required for the enlargement of the canal has been completed. The winter was very favorable for work, and much has been accomplished. The excavation for the deepening and widening of the greater portion of the

old prism and the pier-revetment for the side of the same were nearly completed, as also the lock-pit for the new lock.

It is extremely important and pressing that there should be no delay in constructing the new locks, as if anything should happen to prevent the use of the old ones, the effect on commerce would be ruinous.

The original estimate of the cost of these locks was \$1,159,330. Of this sum there remains \$560,000 to be appropriated, and at least \$300,000 of this should be made available for the fiscal year ending June 30, 1876.

Balance in Treasury of United States July 1, 1873	\$524, 038 00
Amount in hands of officer and subject to his check, (including \$20,472.52 percentage due on contracts not yet completed)	118, 584 59
Amount appropriated by act approved June 23, 1874	200, 000 00
Amount expended during the fiscal year ending June 30, 1874	261, 599 24
Amount available July 1, 1874	534, 062 81
Amount required for the fiscal year ending June 30, 1876	300, 000 00

(See Appendix D 1.)

2. *St. Mary's River, Michigan.*—A survey of the Hay Lake Channel has been made, to form an estimate of the cost of its improvement. By this channel the distance to the Sault St. Mary's Canal is shortened eleven miles, and vessels would be enabled to navigate it at all hours, the Lake St. George Channel, now used, being only practicable by day. The opening of this channel, however, involves the serious expense of rock-excavation through West Neebish Rapids.

(See Appendix D 2.)

3. *Cheboygan Harbor, Michigan.*—The operations here have consisted in continuing the dredging of a channel 13 feet deep across the bar, under the appropriation of March 3, 1873. Seventy-six thousand nine hundred and fifty-five cubic yards were dredged during the fiscal year. The work already done has been of much benefit to the general commerce of the lakes.

The officer in charge submits an estimate of \$60,000 for the next fiscal year.

Balance in Treasury of United States July 1, 1873	\$15, 000 00
Amount in hands of officer and subject to his check, (including \$773.29 percentage due on contracts not yet completed)	6, 934 80
Amount appropriated by act approved June 23, 1874	15, 000 00
Amount expended during the fiscal year ending June 30, 1874	21, 211 51
Amount available July 1, 1874	15, 000 00
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office)	30, 000 00

(See Appendix D 3.)

4. *Mouth of Au Sable River, Michigan.*—The operations during the year consisted in dredging a channel 10 feet in depth across the bar of the river and keeping existing structures in repair.

Attention is again called by the officer in charge to the encroachments upon the channel of the river by private parties, which tend to neutralize the good effects of the Government work.

Balance in Treasury of United States July 1, 1873	\$4, 980 50
Amount in hands of officer and subject to his check	5, 039 40
Amount expended during the fiscal year ending June 30, 1874	6, 842 25
Amount available July 1, 1874	3, 177 65

(See Appendix D 4.)

5. *Saginaw River, Michigan.*—The main obstruction in this river is the Carrolton Bar, where it is proposed to confine the water by means of a double row of piling, to be driven on the eastern side of the river. The

other obstructions are lesser bars, which it is believed may be removed by dredging. The cost of the whole improvement is estimated at \$56,000. The appropriation of June 23, 1874, will be applied to the commencement of this work.

The location of certain private docks have undoubtedly had an injurious effect upon this stream, and the officer in charge of this improvement calls attention to the necessity of such legislation as will enable those in charge of river-improvements to prevent the injuries complained of.

Balance in Treasury of United States July 1, 1873.....	\$292 89
Amount appropriated by act approved June 23, 1874	15,000 00
Amount available July 1, 1874.....	15,292 89
Amount required for the fiscal year ending June 30, 1876.....	45,000 00

(See Appendixes D 5 and D 6.)

6. *Harbor of Refuge, Lake Huron.*—During the fiscal year four cribs of the breakwater were placed in position and made secure, and all preliminary arrangements for prosecuting the work vigorously made, and all the necessary boats, derricks, dredges, and machinery furnished. The officer in charge reports the work so far done as good, with fair prospects for good progress in future.

Balance in Treasury of United States July 1, 1873.....	\$242,800 00
Amount in hands of officer and subject to his check	15,825 02
Amount appropriated by act approved June 23, 1874	75,000 00
Amount expended during the fiscal year ending June 30, 1874.....	33,716 26
Amount available July 1, 1874	299,908 76
Amount required for the fiscal year ending June 30, 1876.....	200,000 00

(See Appendix D 7.)

7. *Saint Clair Flats Ship-Canal.*—The work of deepening this canal to 16 feet, 200 feet wide, is nearly completed; 194,657½ cubic yards of material were dredged during the year, and it is expected that the whole amount required will be dredged for less than the estimate. No further appropriation is required.

Balance in Treasury of United States July 1, 1873.....	\$100,000 00
Amount in hands of officer and subject to his check	547 19
Amount expended during the fiscal year ending June 30, 1874.....	45,153 53
Amount available July 1, 1874	55,393 66

(See Appendix D 8.)

8. *Mouth of Black River, St. Clair River, Michigan.*—The bar at the mouth of Black River has been dredged to the depth of 13 feet throughout, and two cuts of 15 feet in depth have been completed. The appropriation of June 23, 1874, will be applied to the continuation of this dredging to a depth of 15 feet.

Estimate submitted by the officer in charge for continuing the work, \$15,000.

Balance in Treasury of United States July 1, 1873	\$15,000 00
Amount in hands of officer and subject to his check, (including \$1,377.95 percentage due on contracts not yet completed).....	1,377 95
Amount appropriated by act approved June 23, 1874.....	15,000 00
Amount expended during fiscal year ending June 30, 1874	15,000 00
Amount available July 1, 1874	15,000 00
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	10,000 00

(See Appendix D 9.)

9. *Improvement of Detroit River.*—The act of June 23, 1874, appropriated \$25,000 for removing bowlders and rocks from Detroit River. At the close of the fiscal year instructions had been given for the expenditure of this appropriation.

A resolution of the House of Representatives of December 18, 1873, calling for an approximate estimate of the expense of deepening and widening the navigable channels of the rivers and waters connecting Lake Huron with Lake Erie for practicable navigation for vessels drawing 20 feet of water, was referred to Majors Comstock and Weitzel, Corps of Engineers, for report thereon.

Their report will be found in Appendix D 10.

HARBORS ON LAKE ERIE.

Officer in charge, Maj. Franklin Harwood, Corps of Engineers.

1. *Monroe Harbor, Michigan.*—The harbor-piers were thoroughly repaired during the year and the bends of the channel protected from abrasion by piling and sheathing. The entire length of the canal-banks needs like protection. This will be applied, during the coming year, as far as practicable, with the appropriation of June 23, 1874. To complete this work, \$40,000, in addition, will be needed. A little annual dredging at the mouth of the harbor may also prove necessary.

Balance in Treasury of United States July 1, 1873.....	\$10,000 00
Amount in hands of officer and subject to his check, (including \$668 76 percentage due on contracts not yet completed).....	7,669 20
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	17,568 54
Amount available July 1, 1874.....	10,100 66
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	20,000 00

(See Appendix E 1.)

2. *Toledo Harbor, Ohio.*—The improvement, by dredging, of the approach to Toledo from Lake Erie, over the shoals in Maumee Bay, in accordance with the plan of a board of engineer-officers approved in January, 1873, was continued during the year, and a channel 15 feet deep and 100 feet wide (except for a distance of half a mile, where it is only 80 feet wide) has been opened from Toledo to the lake. Future appropriations will be applied to the completion of this plan.

The officer in charge submits an estimate of \$325,000 for completing the work during the next fiscal year.

Balance in Treasury of United States July 1, 1873.....	\$85,000 00
Amount in hands of officer and subject to his check.....	15,536 34
Amount appropriated by act approved June 23, 1874.....	75,000 00
Amount expended during the fiscal year ending June 30, 1874.....	100,017 57
Amount available July 1, 1874.....	75,518 77
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	200,000 00

(See Appendix E 2.)

3. *Port Clinton Harbor, Ohio.*—The catch-sand fence referred to in my last annual report was built on the north spit at the mouth of Portage River to prevent its encroachment on the channel. It has answered its purpose excellently, but may possibly need extension from time to time. No further improvement can be effected short of the extensive project, referred to in previous annual reports, of a cut through the bar at the river's mouth and the construction of piers to confine the waters of the river to the new opening.

Amount in hands of officer and subject to his check, (including \$318.54 percentage due on contracts not yet completed).....	\$4,674 62
Amount expended during the fiscal year ending June 30, 1874.....	4,420 97
Amount available July 1, 1874.....	253 65

(See Appendix E 3.)

4. *Sandusky City Harbor, Ohio.*—A channel 15 feet in depth and 75 feet wide has been dredged through the shoal in the bay. A further widening to 100 feet is advisable, but in order to render it accessible extensive dredging will be required on the outer bar.

The appropriation of June 23, 1874, will be expended upon this.

The officer in charge submits an estimate for continuing the work during the next fiscal year of \$105,000.

Balance in Treasury of United States July 1, 1873.....	\$20,000 00
Amount in hands of officer and subject to his check, (including \$719.61 percentage due on contracts not yet completed).....	10,023 78
Amount appropriated by act approved June 23, 1874.....	25,000 00
Amount expended during the fiscal year ending June 30, 1874.....	30,006 93
Amount available July 1, 1874.....	25,016 85
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	50,000 00

(See Appendix E 4.)

5. *Huron Harbor, Ohio.*—The repairs mentioned in the last annual report have been completed, and the harbor is now in excellent condition. It only remains to repair the piers and dredge a shoal at the base of the west pier, most of which will be done during the present year.

A further appropriation of \$1,000 will complete the work at this harbor.

Balance in Treasury of United States July 1, 1873.....	\$3,300 00
Amount in hands of officer and subject to his check.....	3,049 21
Amount appropriated by act approved June 23, 1874.....	1,500 00
Amount expended during the fiscal year ending June 30, 1874.....	5,123 26
Amount available July 1, 1874.....	2,725 95
Amount required for the fiscal year ending June 30, 1876.....	1,000 00

(See Appendix E 5.)

6. *Vermillion Harbor, Ohio.*—During the fiscal year the extension of the piers was completed, as well as blasting and dredging in the channel, so that now ready access is had to the interior harbor. The appropriation of June 23, 1874, will be applied to repairs of the older parts of the piers, for the completion of which the sum of \$3,000 will be required for the next fiscal year.

As the commerce of this place is rapidly growing, the widening of the channel to 100 feet, with an increase of its depth to 14 feet, is urged by those interested in its trade. It is estimated that \$10,000 will suffice for this purpose, which sum is included in the estimate submitted below of the amount required for the next fiscal year.

Balance in Treasury of United States July 1, 1873.....	\$9,000 00
Amount in hands of officer and subject to his check, (including \$149.60 percentage due on contracts not yet completed).....	5,083 83
Amount appropriated by act approved June 23, 1874.....	3,000 00
Amount expended during the fiscal year ending June 30, 1874.....	14,083 83
Amount available July 1, 1874.....	3,000 00
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	13,000 00

(See Appendixes E 6 and E 7.)

7. *Black River Harbor, Ohio.*—The work of pier-extension was continued during the year, but with some delay, owing to the difficulty of procuring the proper timber.

During the open months of the past winter the work stood the test of severe storms, carrying with them large masses of ice, and has suffered comparatively slight damage, and that only above the water-line. Two hundred and twenty lineal feet of superstructure remain to be laid to

complete the extension of 1873. The plan of improvement adopted is to extend the piers to 15 feet water, and there permanently close the construction; otherwise the bar recently dredged will, in the course of time, re-form, and will require annual dredging. With the piers thus extended the harbor will be for many years accessible to deepest-draught vessels. The dredging on the bar was satisfactory, resulting in a depth of 14 feet of water.

Balance in Treasury of the United States July 1, 1873	\$14,003 78
Amount in hands of officer and subject to his check, (including \$1,566.53 percentage due on contracts not yet completed)	11,092 08
Amount appropriated by act approved June 23, 1874	20,000 00
Amount expended during the fiscal year ending June 30, 1874	25,551 02
Amount available July 1, 1874	18,281 88
Amount required for the fiscal year ending June 30, 1876	10,000 00

(See Appendix E 8.)

8. *Rocky River Harbor, Ohio.*—Three hundred and sixty feet of pier were built at this point during the year, exhausting the appropriation. The appropriation of June 23, 1874, is, by the terms of the act, to be expended in preserving and continuing the work upon the pier. The construction of a permanent harbor will require a large outlay. If, however, this harbor is to be established, it would be most economical to complete it in one season, and the officer in charge submits an estimate of \$240,000 therefor.

Balance in Treasury of United States July 1, 1873	\$1,000 00
Amount in hands of officer and subject to his check	7,722 37
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874	8,722 37
Amount available July 1, 1874	10,000 00
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office)	30,000 00

(See Appendix E 9.)

9. *Cleveland Harbor, Ohio.*—The most pressing repairs of the piers have been attended to, exhausting the appropriation. The appropriation of June 23, 1874, will be needed to put the piers in good order, which can be done during the present fiscal year.

A survey "for the construction of a harbor of refuge" at this locality was made in compliance with the provisions of the river and harbor act of March, 1873, and a report, with project and estimate of cost, was submitted to Congress January 24, 1874, and printed in Ex. Doc. No. 84, H. R., Forty-third Congress, first session. The plan submitted by the officer in charge of the survey is that of a breakwater of crib-work of 40 feet in width, resting in an average depth of water of 34 feet; to consist of two arms of 4,000 feet in length each, making an angle with each other of about 138°, the apex to be about 3,000 feet in front of the ends of the present piers of entrance, and embracing an anchorage of about 260 acres.

The bottom of the lake consists here of a loose deposit of soft blue clay, silt, and sand, no rock or firm foundation of any kind being found within a penetration of 25 feet. An approximate estimate was presented by the officer in charge, Major Harwood, of \$4,000,000, as the probable maximum cost of the plan he submits.

In view of the magnitude of the undertaking and the great cost of the plan above referred to, Congress directed in the river and harbor improvement act of June 23, 1874, a survey to be made for a breakwater at Cleveland, with a view to obtaining a new estimate for four fathoms water.

The report upon this latter survey will be submitted to Congress during its next session.

Balance in Treasury of United States July 1, 1873	\$1,000 00
Amount appropriated by act approved June 23, 1874	30,500 00
Amount expended during the fiscal year ending June 30, 1874	1,000 00
Amount available July 1, 1874	30,500 00

(See Appendix E 10.)

10. *Grand River Harbor, Ohio.*—The extension of the piers was continued last season until the appropriation was exhausted, leaving to be executed the building of 270 feet of superstructure and completion of 300 feet of same at west pier, the placing of the beacon-crib, the building of 209 feet at east pier, and the completion of 91 feet of its superstructure. A freset made a breach at the base of the east pier, which must be stopped by prolonging the pier across it. Sheath-piling is also required to protect the shore-end of the west pier. The pier being completed, the harbor will be an excellent one.

Balance in Treasury of United States July 1, 1873.....	\$13,664 59
Amount in hands of officer and subject to his check, (including \$3,437.05 percentage due on contracts not yet completed).....	9,407 19
Amount appropriated by act approved June 23, 1874	20,000 00
Amount expended during the fiscal year ending June 30, 1874.....	23,071 78
Amount available July 1, 1874	20,000 00
Amount required for the fiscal year ending June 30, 1876.....	15,000 00

(See Appendix E 11.)

11. *Ashtabula Harbor, Ohio.*—A channel 60 feet wide and 14 feet deep, low stage, was completed from the harbor to the lake during the fiscal year. It should be widened to 100 feet to allow vessels to pass each other freely. Before this can be undertaken, in order to keep the present channel open, it will be necessary to stop the influx of sand from the west. To do this, the west pier must be extended lakeward to at least 14 feet water.

Balance in Treasury of United States July 1, 1873	\$10,000 00
Amount in hands of officer and subject to his check	5,997 10
Amount appropriated by act approved June 23, 1874	35,000 00
Amount expended during the fiscal year ending June 30, 1874.....	15,973 63
Amount available July 1, 1874	35,023 47
Amount required for the fiscal year ending June 30, 1876.....	45,000 00

(See Appendix E 12.)

12. *Conneaut Harbor, Ohio.*—This harbor is in good condition, requiring only minor repairs to piers, for which the present estimate is made.

Balance in Treasury of United States July 1, 1873.....	\$400 00
Amount appropriated by act approved June 23, 1874	1,500 00
Amount expended during the fiscal year ending June 30, 1874	399 55
Amount available July 1, 1874	1,500 45
Amount required for the fiscal year ending June 30, 1876.....	1,000 00

(See Appendix E 13.)

13. *Erie Harbor, Pennsylvania.*—Dredging in the channel and at the mouth of the harbor was continued during the fiscal year. The gales of the autumn and winter made serious attacks on existing protections to Presque Isle and the harbor, to meet which there are needed a beach-protection at the north spit at the entrance, a thorough repair of the north pier, and a replanting of the neck of the peninsula with willow. A small amount of dredging is also annually required at the entrance of the harbor.

The appropriation of June 23, 1874, will be expended in the above work, as far as it will admit.

Balance in Treasury of United States July 1, 1873	\$3,000 00
Amount in hands of officer and subject to his check, (including \$327.81 percentage due on contracts not yet completed).....	2,320 81

Amount appropriated by act approved June 23, 1874.....	\$20,000 00
Amount expended during the fiscal year ending June 30, 1874.....	10,195 28
Amount available July 1, 1874	20,125 53
Amount required for the fiscal year ending June 30, 1876.....	80,000 00

(See Appendix E 14.)

14. *Dunkirk Harbor, New York.*—At the close of the fiscal year the channel was partly dredged and the breakwater prolonged westwardly to its edge, but not completely finished in superstructure. Sixty feet of under-water work was added to the easterly end. The channel can be completed and the breakwater, which is now 540 feet long, finished to 600 feet by the close of the present fiscal year. The harbor will then be an excellent one, and will become better and better as the breakwater is prolonged to the eastward.

For continuing the work during the next fiscal year the officer in charge submits an estimate of \$100,000.

Balance in Treasury of United States July 1, 1873.....	\$30,000 00
Amount in hands of officer and subject to his check.....	8,736 86
Amount appropriated by act approved June 23, 1874.....	35,000 00
Amount expended during the fiscal year ending June 30, 1874.....	36,130 56
Amount available July 1, 1874	37,606 39
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office)	50,000 00

(See Appendix E 15.)

15. *Buffalo Harbor, New York.*—The damage to the breakwater by the fall and winter gales of 1872 was repaired and the work continued 100 feet, making in all 2,499 feet of completed work. The severe gale of December 4, 1873, injured the foundation of the new work, which has settled to the water-level, having separated it from the work of 1872, which was also damaged extensively in superstructure. Damages were repaired as far as practicable. For want of funds no further progress was made, and the work stood at the close of the fiscal year as the gale had left it. The lakeward side of the breakwater was badly cut by floating ice during the winter, and will have to be iron-plated near the water-level.

The gale of December 4, 1873, caused a large accumulation of sand at the head of the south or light-house pier, which required removal before the opening of navigation, and a special appropriation of \$20,000 was made by Congress February 25, 1874, for this purpose. The sand was accordingly removed in time to obviate all danger to the channel.

A board of engineers was convened at Buffalo to consider and report upon a plan to prevent future encroachment of sand at the mouth of Buffalo River, and upon examination approved the project of the officer in charge of the work (Major Harwood) to build a catch-sand pier in the vicinity of the proposed south channel; this to be a pile-pier 10 feet in width covered by 6 feet of superstructure and extending to the 12-foot curve; thence prolonged in the same direction by crib-work 20 feet in width, covered with 6 feet of superstructure to a designated point. In addition to the catch-sand pier, the board anticipated that other jetties of slight construction, not to exceed 300 feet in length, might be needed at different points between the site of the one proposed and the south United States pier, to arrest the transfer of sand and prevent the abrasion of the beach during the period in which the breakwater was in course of construction.

The board directed minute and careful examination and survey to be made of the vicinity of the breakwater, with a view to ascertain by frequent borings the exact character of the bottom, having in view a

possible change of direction of the present breakwater and the projection of a plan for additional protection, as recommended by the officer in charge of the work. The survey and examination were delayed for want of funds necessary to the prosecution, but are now in progress.

The officer in charge submits an estimate, for continuing the work during the next fiscal year, of \$500,000.

Balance in Treasury of United States July 1, 1873.....	\$45,000 00
Amount in hands of officer and subject to his check, (including \$2,037.94 percentage due on contracts not yet completed).....	10,301 83
Amount appropriated by acts approved February 25 and June 23, 1874...	95,000 00
Amount expended during the fiscal year ending June 30, 1874	73,000 68
Amount available July 1, 1874	77,301 15
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office)	200,000 00

(See Appendixes E 16 and E 17.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Major Harwood was instructed, to comply with provisions of the act of March 3, 1873, to make the necessary examinations and surveys for the preparation of an estimate for the construction of a *harbor of refuge at Cleveland*. His report thereon was transmitted to Congress at its last session.

(See Appendix E 18.)

HARBORS ON LAKE ONTARIO AND THE RIVER ST. LAWRENCE.

Officer in charge, Maj. John M. Wilson, Corps of Engineers.

1. *Olcott Harbor, New York*.—Operations were carried on during the year both upon the construction of the piers and dredging the channel.

The superstructure upon 90 feet of the west pier was filled with stone and decked over and entirely constructed upon 120 feet of the east pier. Two thousand three hundred and eighty-six yards of red shale and rock, 13,428 cubic yards of clay, sand, gravel, and mud, one old crib, a large boulder, and the wreck of an old vessel were removed from the channel by dredging.

During the present season it is proposed to open a channel 50 feet wide between the piers by the removal of rock.

The officer in charge submits an estimate of \$30,000 for continuing the work during the next fiscal year.

Balance in Treasury of United States July 1, 1873.....	\$10,200 00
Amount in hands of officer and subject to his check, (including \$724.99 percentage due on contracts not yet completed).....	1,531 76
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	11,720 44
Amount available July 1, 1874	10,011 32
Amount required for the fiscal year ending July 30, 1876, (as revised in this Office)	10,000 00

(See Appendix F 1.)

2. *Oak Orchard Harbor, New York*.—Operations during the fiscal year were carried on with hired labor, drilling, blasting, and excavating rock, &c., from the channel between the piers; 1,132 holes, amounting to 4,356 lineal feet, have been drilled and blasted under water, varying from 7 to 11 feet in depth; 3,503 cubic yards of red shale and rock and 1,958.21 cubic yards of mud, sand, gravel, &c., have been removed by dredging.

During the present season it is proposed to level up the piers where

settlement has taken place, to continue drilling and blasting rock in the channel, and to continue dredging.

The officer in charge submits an estimate of \$15,000 for continuing the work during the next fiscal year.

Balance in Treasury of United States July 1, 1873.....	\$10,673 73
Amount in hands of officer and subject to his check.....	16 97
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	10,623 06
Amount available July 1, 1874.....	10,067 64
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	10,000 00

(See Appendix F 2.)

3. *Charlotte Harbor, New York.*—Operations have been confined during the year to those absolutely necessary for the preservation of the piers, and have consisted of minor repairs at various points.

There are no available funds for the present fiscal year.

Amount expended during the fiscal year ending June 30, 1874, from appropriation for examination, survey, &c., act of 1870.....	\$634 32
Amount required for the fiscal year ending June 30, 1876.....	5,000 00

(See Appendix F 3.)

4. *Pultneyville Harbor, New York.*—Operations during the year have been carried on under contract constructing the east pier, 212 lineal feet of which have been built; of this length 122 feet were in water 10 feet deep and 90 feet in water 6 feet deep.

During the present season it is proposed to add 110 lineal feet to the west pier, the cribs to be sunk in an average depth of 10 feet, and to open the channel by dredging.

The officer in charge submits an estimate for \$19,000 for continuing the work during the next fiscal year.

Balance in Treasury of the United States July 1, 1873.....	\$10,800 00
Amount in hands of officer and subject to his check.....	1,788 28
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	12,588 28
Amount available July 1, 1874.....	10,000 00
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	10,000 00

(See Appendix F 4.)

5. *Great Sodus Harbor, New York.*—Operations during the year comprised dredging the channel between the piers and repairing the east breakwater; 16,808 cubic yards of sand and gravel have been removed, and 158 feet of the east breakwater completed.

During the present season it is proposed to remove sand, gravel, &c., from the channel between the piers, and to rebuild about 350 lineal feet of the east breakwater.

The officer in charge submits an estimate of \$20,000 for continuing the work during the next fiscal year.

Balance in Treasury of United States July 1, 1873.....	\$55 84
Amount in hands of officer and subject to his check, (including \$666.32 percentage due on contracts not yet completed).....	4,694 40
Amount appropriated by act approved June 23, 1874.....	15,000 00
Amount expended during the fiscal year ending June 30, 1874.....	4,694 40
Amount available July 1, 1874.....	15,055 84
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	15,000 00

(See Appendix F 5.)

6. *Little Sodus Harbor, New York.*—During the fiscal year operations have been carried on under contract constructing the east pier and

breakwater. Two hundred and forty-three lineal feet of pier complete have been added to the east pier, and 60 feet of superstructure upon cribs previously sunk. One hundred and ten feet complete of the east breakwater have been constructed, and 130 feet additional completed, except one course of timber.

During the present season it is proposed to construct 540 lineal feet of the east breakwater, to complete the filling of the east pier, and to repair the decking upon about 600 feet of the west pier.

The officer in charge submits an estimate of \$27,000 for continuing the work during the next fiscal year.

Balance in Treasury of United States July 1, 1873	\$15,555 33
Amount in hands of officer and subject to his check, (including \$627.29, percentage due on contracts not yet completed)	4,917 15
Amount appropriated by act approved June 23, 1874	15,000 00
Amount expended during the fiscal year ending June 30, 1874	20,417 15
Amount available July 1, 1874	15,055 33
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office)	15,000 00

(See Appendix F 6.)

7. *Oswego Harbor, New York.*—The old pier was very badly injured by the winter-storms, and has required extensive repairs, involving the almost entire rebuilding of a large portion of it. These repairs are nearly completed. Four hundred feet of crib-work complete have been added to the line of the new pier, and 90 feet placed in rear of it for counterforts; 1,125 lineal feet of superstructure have been completed.

During the present season it is proposed to complete the repairs of the old pier and to add about 520 lineal feet to the new pier, 460 feet to be upon the prolongation of the present line of the pier, and 60 feet in rear as counterforts.

The officer in charge submits an estimate of \$300,000 for continuing the work during the next fiscal year.

Balance in Treasury of United States July 1, 1873	\$107,156 24
Amount in hands of officer and subject to his check	5,350 14
Amount appropriated by act approved June 23, 1874	75,000 00
Amount expended during the fiscal year ending June 30, 1874	112,157 34
Amount available July 1, 1874	75,349 04
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office)	200,000 00

(See Appendix F 7.)

8. *Mouth of Black River, New York.*—Operations during the year have consisted in dredging a channel 3,000 feet long, 20 feet wide, and 7 feet deep through the bar at the mouth of the river, removing, in all, 11,500 cubic yards of sand, mud, and sawdust. The heavy gales of September caused this channel to fill up again, as was anticipated.

There are no funds available for the present fiscal year.

Balance in Treasury of United States July 1, 1873	\$4,600 00
Deduct this sum, expended in last fiscal year	24 29
Amount expended during the fiscal year ending June 30, 1874	4,575 71
Amount required for the fiscal year ending June 30, 1876, if it is proposed to carry on the work	50,000 00

(See Appendix F 8.)

9. *Ogdensburg Harbor, New York.*—Operations have been in progress dredging under contract the channel parallel to the line of docks, and widening and deepening that over the bar near the light-house; 6,130 cubic yards of mud, sand, and gravel have been removed from the former channel, and 3,000 cubic yards from the latter.

During the present season it is proposed to complete the channel in

the St. Lawrence River, parallel to the line of docks, to a width of 150 feet, and to widen and deepen the channel over the bar near the light-house.

Balance in Treasury of United States July 1, 1873.....	\$3,092 72
Amount in hands of officer and subject to his check.....	2,644 97
Amount appropriated by act approved June 23, 1874.....	6,000 00
Amount expended during the fiscal year ending June 30, 1874.....	5,737 69
Amount available July 1, 1874.....	6,000 00
Amount required for the fiscal year ending June 30, 1876.....	5,000 00

(See Appendix F 9.)

10. *Waddington Harbor, New York.*—During the fiscal year a channel has been dredged through the bar at the head of Little River, the upper entrance to the harbor of Waddington, by removing 8,728 cubic yards of bowlders, cobble-stone, stiff clay, mud, &c. The channel was 400 feet long, 200 feet wide, and the depth of 11 feet at low water was obtained.

During the present season it is proposed to widen and deepen the inner end of the channel over the bar, and to widen and deepen the channel near the ferry-docks below the dam.

Balance in Treasury of United States July 1, 1873.....	\$6,700 00
Amount in hands of officer and subject to his check.....	3,270 25
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	9,957 94
Amount available July 1, 1874.....	10,012 31

(See Appendix F 10.)

HARBORS ON LAKE CHAMPLAIN—IMPROVEMENT OF OTTER CREEK, VERMONT.

Officer in charge, Lieut. Col. John Newton, Corps of Engineers.

1. *Plattsburgh Harbor, New York.*—During the year the superstructure of the extension to the breakwater of 100 feet was completed, and the crib-work for an extension of 56 feet was sunk and filled with stone, and the superstructure will be completed between July 1 and December 31, 1874.

Under appropriation of June 23, 1874, it is proposed to repair the south end of the old breakwater.

Balance in Treasury of United States July 1, 1873.....	\$10,000 00
Amount in hands of officer and subject to his check.....	5,095 67
Amount appropriated by act approved June 23, 1874.....	5,000 00
Amount expended during the fiscal year ending June 30, 1874.....	8,242 88
Amount available July 1, 1874.....	10,116 79

(See Appendix G 1.)

2. *Burlington Harbor, Vermont.*—During the year the superstructure of the extension to the breakwater of 180 feet has been completed, and two cribs for an extension of 220 feet in a southerly direction have also been sunk and filled with stone, the superstructure of which will be completed between July 1 and December 31, 1874.

Under appropriation of June 23, 1874, it is proposed to extend the breakwater about 137 feet from the north end in direction nearly north-west.

Balance in Treasury of United States July 1, 1873.....	\$40,145 99
Amount in hands of officer and subject to his check.....	11,440 51
Amount appropriated by act approved June 23, 1874.....	25,000 00
Amount expended during the fiscal year ending June 30, 1874.....	39,742 61
Amount available July 1, 1874.....	27,460 89
Amount required for the fiscal year ending June 30, 1876.....	40,000 00

(See Appendix G 2.)

3. *Swanton Harbor, Vermont.*—During the year one crib 110 feet long for a breakwater has been constructed, and the superstructure will be constructed between July 1 and December 31, 1874.

Under appropriation of June 23, 1874, for \$8,000, it is proposed to continue the breakwater in the present northwesterly line.

The officer in charge submits an estimate of \$249,160 for completing the work.

Balance in Treasury of United States July 1, 1873.....	\$15,000 00
Amount appropriated by act approved June 23, 1874.....	8,000 00
Amount expended during fiscal year ending June 30, 1874.....	8,241 65
Amount available July 1, 1874.....	10,193 35
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	20,000 00

(See Appendix G 3.)

4. *Improving Otter Creek, Vermont.*—During the year dredging has been done at the following points: Brick-yard, 3,200 cubic yards material removed; Smith's Bend, 6,000 cubic yards material removed; Bull Brook, 4,762 cubic yards material removed; Vergennes Basin, 5,750 cubic yards material removed, consisting of clay, sand, gravel, silt, stone, and saw-mill *débris*. This improvement enables vessels to reach the wharves at any point on the east side of the basin.

Balance in Treasury of United States July 1, 1873.....	\$7,500 00
Amount in hands of officer and subject to his check.....	2,074 00
Amount expended during the fiscal year ending June 30, 1874.....	9,346 86
Amount available July 1, 1874.....	227 27
Amount required for the fiscal year ending June 30, 1876, to complete the improvement.....	48,000 00

(See Appendix G 4.)

WESTERN RIVERS AND GULF OF MEXICO.

PRESERVATION OF THE FALLS OF ST. ANTHONY—CONSTRUCTION OF LOCK AND DAM AT MEEKER'S ISLAND—IMPROVEMENT OF MINNESOTA RIVER.

Officer in charge, Maj. F. U. Farquhar, Corps of Engineers.

1. *Preservation of the Falls of St. Anthony.*—Attention is invited to the annual report of Major Farquhar, and to the report of the board of engineer officers constituted to consider the subject of the preservation of these falls, which will be found in the appendix to this communication; from which it will be seen that the longer the construction of all the works necessary for the preservation of the falls is delayed the greater will be their cost, as large sums have been expended in meeting continually occurring emergencies, which would not have taken place had the means provided been sufficient to proceed at once with the main works.

The work of the last fiscal year consisted in placing that which had already been done beyond the danger arising from breaks under the lime-rock into the tunnel near the head of the ledge. A contribution of \$17,157.50 from the citizens of Minneapolis was also used to the same end.

The board of engineer officers recommend the following expenditures: For dam on the surface of the rock, \$24,420; repair and extension of the aprons to protect the lower end of the falls, \$65,000; completion of the dike under the limestone-rock, \$130,000; and construction of the walls at the head of the limestone-rock, \$200,000; in all, \$419,792. Of this sum there was available on July 1, 1874, \$125,000, leaving still re-

quired \$294,792, of which there could be profitably used during the fiscal year ending June 30, 1876, \$200,000.

During the present fiscal year it is proposed to commence the watertight wall or dike recommended by the board of engineers.

Balance in Treasury of United States July 1, 1873.....	\$20,000 00
Amount in hands of officer, and subject to his check, (including \$5,244.62 due on material not yet paid for).....	21,880 78
Amount appropriated by act approved June 23, 1874.....	150,000 00
Amount expended during the fiscal year ending June 30, 1874.....	35,147 63
Amount available July 1, 1874.....	151,488 53
Amount required for the fiscal year ending June 30, 1876.....	200,000 00

(See Appendixes H 1 and H 2.)

2. *Lock and dam at Meeker's Island, Minnesota.*—No work was done, as the provisions of the act approved March 3, 1873, were not complied with by parties holding the land-grant until the spring of this year. Some borings will be necessary before a final estimate of the cost of this work can be made. From known data it is estimated that the cost of the lock and dam will be about \$922,121.46, and if the work is to be prosecuted a sum of not less than \$300,000 should be appropriated for the fiscal year ending June 30, 1876.

Balance in Treasury of United States July 1, 1873.....	\$25,000 00
Amount available July 1, 1874.....	25,000 00
Amount required for the fiscal year ending June 30, 1876.....	300,000 00

(See Appendix H 3.)

3. *Improvement of Minnesota River, Minnesota.*—The work during the fiscal year consisted in the removal of a large number of bowlders and snags from the river and a small amount of rock in place, which nearly exhausted the available funds.

It is proposed to use the appropriation of June 23, 1874, for a detailed survey of the river, in order to plan and estimate the cost of improving the river by means of dams and locks. It is recommended that \$60,000 be appropriated for a lock and dam at Little Rapids.

Balance in Treasury of United States July 1, 1873.....	\$5,000 00
Amount in hands of officer and subject to his check.....	6,379 72
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	9,975 25
Amount available July 1, 1874.....	11,404 47
Amount required for the fiscal year ending June 30, 1876.....	60,000 00

(See Appendix H 4.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Major Farquhar was charged with and has reported upon the following surveys provided for in the act of March 3, 1873 :

1. *Galena River, from its mouth to Galena, Illinois.*

(See Appendix H 5.)

2. *Red River of the North, from Moorehead to Pembina.*

(See Appendix H 6.)

To comply with a request from the Board of Trade of Minneapolis, an examination was made in December last, under the direction of Major Farquhar, of the Mississippi River between St. Cloud and the falls of St. Anthony, with the view of forming an approximate estimate of the cost of improving the river between those points.

For the result of this examination see Appendix H 7.

IMPROVEMENT OF THE UPPER MISSISSIPPI BETWEEN ST. PAUL, MINNESOTA, AND GRAFTON, ILLINOIS.—IMPROVEMENT OF DES MOINES AND ROCK ISLAND RAPIDS OF THE MISSISSIPPI RIVER, AND IMPROVEMENT OF THE ILLINOIS RIVER.

Officer in charge, Col. J. N. Macomb, Corps of Engineers, having under his immediate orders Capt. Amos Stickney, Corps of Engineers.

1. *Improvement of Upper Mississippi River.*—The steamer Montana, in charge of Capt. J. B. Davis, a river-captain of experience, was employed as heretofore in dredging sand-bars and rendering temporary aid to the navigation in advance of the permanent system to be projected for improving this section of the river.

Until the plans for permanent improvement can be perfected in pursuance of surveys now in progress, it is recommended that the plan of temporary aid be continued as asked for by the engineer in charge.

Balance in Treasury of United States July 1, 1873.....	\$25,000 00
Deduct amount expended in last fiscal year.....	2,527 30
Amount appropriated by act approved June 23, 1874.....	25,000 00
Amount expended during the fiscal year ending June 30, 1874.....	22,656 62
Amount available July 1, 1874.....	25,019 99
Amount required for the fiscal year ending June 30, 1876.....	25,000 00

(See Appendix I 1.)

2. *Improving Des Moines Rapids, Mississippi River.*—During the past fiscal year the work of improvement has consisted of earth and rock excavation from the prism of the canal, riprapping canal-bank, building dike, and making the excavation for the foundation of the guard-lock, and excavations of channels at entrances of the canal; this work having been done by Messrs. J. W. Kittle & Co., under their contract dated 30th August, 1873. Owing to difficulties under which this work was prosecuted, the time for completing the work embraced in this contract was extended to October 31, 1874. The contracts with Messrs. Dull and Williams for the lower lock, and Willard Johnson for the middle lock, were completed soon after the commencement of the year.

Coffer-dams for excavations at the entrances to the canal, services at the middle and lower locks, repairing leak under the embankment, and the general finishing of the lower and middle sections, were in progress during the year by hired labor, and the purchase of materials in open market, under the direct superintendence of the engineer in charge, with the most satisfactory results.

Balance in Treasury of United States July 1, 1873.....	\$400,000 00
Amount in hands of officer and subject to his check, (including \$18,230.12 percentage due on contracts not yet completed).....	66,300 00
Amount appropriated by act approved June 23, 1874.....	400,000 00
Amount expended during the fiscal year ending June 30, 1874.....	344,987 18
Amount available July 1, 1874.....	505,807 10
Amount required for the fiscal year ending June 30, 1876.....	420,000 00

(See Appendix I 2.)

3. *Improving Rock Island Rapids, Mississippi River.*—The improvements at Lower Chain, Duck Creek Chain, and under the head of at "various places" have been effected. Owing to the smallness of the last appropriation and the increased prices of excavation but 3,330 cubic yards can be removed, leaving 3,809 cubic yards to be taken out at the foot of Moline Chain, at various places on the rapids, and probably still a small amount at Lower Chain, for the final accomplishment of which, and for meeting all probable contingencies in completing the work, the officer in charge most earnestly asks an appropriation of \$80,000.

Balance in Treasury of United States July 1, 1873.....	\$50,000 00
Amount in hands of officer and subject to his check, (including \$2,999 percentage due on contracts not yet completed).....	4,034 74

Amount appropriated by act approved June 23, 1874.....	\$50,000 00
Amount expended during the fiscal year ending June 30, 1874	51,694 04
Amount available July 1, 1874	52,340 70
Amount required for the fiscal year ending June 30, 1876	80,000 00

(See Appendix I 3.)

4. *Improving Illinois River.*—Owing to the earnest request of the governor of Illinois, and others interested in continuing this improvement in accordance with the approved project of a lock and dam navigation, some four-fifths of the last appropriation were set apart for putting in the lock-bottom for the second lock; this is just below Copperas Creek. The remainder of the appropriation was devoted to dredging at those points most in need of such improvements, in advance of extending the lock and dam system below Copperas Creek.

The amount of \$150,000 is asked to be applied to this work in coming fiscal year.

Balance in Treasury of United States July 1, 1873.....	\$95,000 00
Amount in hands of officer and subject to his check.....	3,719 19
Amount appropriated by act approved June 23, 1874	75,000 00
Amount expended during the fiscal year ending June 30, 1874	52,796 75
Amount available July 1, 1874	118,104 44
Amount required for the fiscal year ending June 30, 1876	150,000 00

(See Appendix I 4.)

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OF THE OHIO, AND IMPROVEMENT OF OSAGE RIVER, MISSOURI.

Officer in charge, Col. J. H. Simpson, Corps of Engineers, having under his immediate orders Capt. Charles J. Allen, Corps of Engineers.

1. *Improvement of Mississippi River between the mouths of the Illinois and Ohio Rivers.*—Work between the Illinois and Missouri Rivers has been limited to the completion of the dam closing the slough behind Ellis Island, opposite Alton, to the height of 8 feet above low water. The materials were purchased in open market and the work done by hired labor.

No specific appropriations are asked for the fiscal year ending June 30, 1876, the amount required being included in general estimate for improvement of Mississippi River between the Illinois and Ohio Rivers.

Amount in hands of officer and subject to his check.....	\$3,021 82
Amount appropriated by act approved June 23, 1874	15,000 00
Amount expended during the fiscal year ending June 30, 1874	3,021 82
Amount available July 1, 1874	15,000 00

Between the Missouri and Ohio Rivers work has been continued at Sawyer's Bend, of which 5,445 lineal feet is now sufficiently protected. The protection will be extended 600 feet the present year, leaving 4,515 feet to be done.

At Venice, what is known as Long Dike has been raised to the height of 14 feet above low water, and the dike extended westwardly 600 feet. Work on the extension was incomplete at the close of the year, but its early completion was assured.

Work was begun at Horsetail Bar, and at the close of the year a decided improvement was obtained, though the incomplete state of the works did not then assure a permanence of decided results. A dike 1,171 feet in length had been completed on the Missouri side, and two dikes on the Illinois side were in an advanced state of progress. The experience gained during the last two years renders the construction of

dikes in the Mississippi a certainty at moderate cost compared with the value of the results attained. The system of construction is no longer experimental, but can be applied generally with assurance of success if skill, care, and forethought be exercised in the location of works and management of construction.

Having passed the experimental stages, the improvement of the Mississippi can hereafter progress as rapidly as the means furnished will permit. The officer in charge estimates that \$600,000 will be required for the year ending June 30, 1876, the appropriation of which sum is recommended.

The *triangulation of the river-bed from the Missouri to the Ohio*, which was in progress at the beginning of the year, has been continued, and at the close of the year was nearly completed. In addition to the triangulation special surveys were made at the several points where work is contemplated the present year. The extension of the triangulation to cover the valley proper, mentioned as important last year, is again recommended. The estimated cost is \$50,000.

Balance in Treasury of United States July 1, 1873.....	\$239,000 00
Amount in hands of officer and subject to his check, (including \$2,712.35 percentage due on contracts not yet completed).....	17,531 33
Amount appropriated by act approved June 23, 1874.....	195,000 00
Amount expended during the fiscal year ending June 30, 1874.....	215,347 62
Amount available July 1, 1874	236,183 71
Amount required for the fiscal year ending June 30, 1876	600,000 00

(See Appendix K 1.)

2. Improvement of Osage River, Missouri.—Operations upon this river were carried on at Dixon's, Round Bottom, Burd's, Lockett's Island, Lockett's, General Bolton's, and Shipley's Shoals, the mode of improvement being the same as that followed during the preceding year, namely, the contraction of the stream by cross-dams, training-dikes, &c., and by excavating the channel. The materials used in the dams and dikes were logs, brush, and stone, and were purchased in open market. The work was performed by hired labor.

Work thus far has resulted in an improvement of the river at the points named, a depth of 2 feet and more at low water having been obtained at most of them.

The further sum of \$25,000 was appropriated by the act approved June 23, 1874. It is proposed to expend the greater part of this amount in continuing the work upon the plan now in progress, using the balance, (say, \$5,000, or so much of the whole as may be necessary,) for the thorough survey from Tuscumbia—to which point it had been carried and suspended—up the river toward Roscoe, a distance of 173 miles, with a view to the permanent improvement of the river by locks and dams, if such method should be found practicable.

Estimates for the further prosecution of the work are delayed until the completion of the survey referred to for slack-water navigation.

Balance in Treasury of the United States July 1, 1873.....	\$40,000 00
Amount in hands of officer and subject to his check	10,594 74
Amount appropriated by act approved June 23, 1874	25,000 00
Amount expended during the fiscal year ending June 30, 1874	47,332 77
Amount available July 1, 1874	28,261 97

(See Appendixes K 2 and K 3.)

IMPROVEMENT OF THE OUACHITA AND YAZOO RIVERS.

Officer in charge, Capt. W. H. H. Benyaurd, Corps of Engineers.

1. Improvement Ouachita River in Louisiana and Arkansas.—Certain amounts of lumber, &c., intended for the foundations of locks at Buffalo

Flats and Jack's Island, in Arkansas, and at Rock Row, in Louisiana, have been delivered. The crane-boat Ouachita was refitted and repaired and operated during the low-water season in removing the most dangerous obstructions to the navigation of the stream, though the frequent rises interfered somewhat with the work.

During the coming season it is proposed to build and operate a new snag-boat.

Applied to Louisiana.

Balance in Treasury of United States July 1, 1873	\$81,000 00
Amount in hands of officer and subject to his check	11,254 07
Amount expended during the fiscal year ending June 30, 1874	30,755 15
Amount available July 1, 1874	61,498 92
Amount required for the fiscal year ending June 30, 1876	13,000 00

Applied to Arkansas.

Balance in Treasury of United States July 1, 1873	\$35,000 00
Amount in hands of officer and subject to his check, (including \$460.50 percentage due on contracts not yet completed)	13,573 05
Amount expended during the fiscal year ending June 30, 1874	30,486 49
Amount available July 1, 1874	18,086 56
Amount required for the fiscal year ending June 30, 1876	13,000 00

(See Appendix L 1.)

A resurvey of the river from Camden, Arkansas, to Trinity, Louisiana, was made during the year, and a report thereon submitted to Congress at its last session, and printed in Ex. Doc. H. R. 259.

(See Appendix L 2.)

2. *Improvement of Yazoo River, Mississippi.*—During the fiscal year nine wrecks were removed from the channel under contracts made with the New Orleans Wrecking and Salvage Company. Eleven more yet remain, together with many beds of sunken logs, forming serious obstructions to the safe navigation of the river.

Balance in Treasury of United States July 1, 1873	\$35,000 00
Amount in hands of officer and subject to his check	5,000 00
Amount expended during the fiscal year ending June 30, 1874	39,023 06
Amount available July 1, 1874	976 94
Amount required for the fiscal year ending June 30, 1876	75,000 00

(See Appendix L 3.)

IMPROVEMENT OF THE MISSISSIPPI, MISSOURI, AND ARKANSAS RIVERS, AND OF THE WHITE AND ST. FRANCIS RIVERS.

Officer in charge, Maj. Charles R. Suter, Corps of Engineers.

1. *Mississippi, Missouri, and Arkansas Rivers.*—The snag-boats employed on this improvement have worked during the past year in the Missouri River from Kansas City, Missouri, to the mouth, three hundred and eighty-five miles, in the Mississippi River from Keokuk, Iowa, to Vicksburg, Mississippi, one thousand and five miles, and for five days by special detail in the Ohio River. The season of field-work was very short, and quite inadequate to the requirements of commerce. This was owing to the small size of the annual appropriation and to the necessity of applying a portion of it (act of January 23, 1873) to paying for a new iron-hulled snag-boat. Owing to a long and unusually high stage of water in the Ohio River, the contractor for this boat has not yet been able to complete it. For this reason no work was done in Arkansas River, which is not accessible to the large deep-draught boats hitherto

employed. It is hoped that this boat will be completed in time to take the field before winter.

The officer in charge renews his recommendation that iron hulls be at once built for the machinery of two of the present wooden boats, which have so deteriorated that they can only be fitted for further effective service at a great cost, and are, moreover, of entirely too great draught for the service required of them; that, after this is done, the remaining wooden boat be fitted up for wrecking purposes, and that, after the iron boats have been fairly tested, two more of a smaller type be built.

Operations during the coming season will be as extensive as the limited appropriation will admit of.

Balance in Treasury of United States July 1, 1873	\$120,988 00
Amount in hands of officer and subject to his check	57,301 23
Amount appropriated by act approved June 23, 1874	100,000 00
Amount expended during the fiscal year ending June 30, 1874	149,389 34
Amount available July 1, 1874	106,399 89
Amount required for the fiscal year ending June 30, 1876	373,000 00

(See Appendix M 1.)

2. *White and St. Francis Rivers.*—Snag-boat operations in these rivers were commenced in January, 1874, and carried on for two months. They extended on White River from the mouth to Jacksonport, three hundred and forty miles, and on the St. Francis from the mouth to Wittsburgh, one hundred and thirty miles. Work was suspended sooner than intended, owing to the great floods which prevailed along the southern rivers during the spring of the present year.

Much snagging-work is still required, especially during low stages of water. For this purpose a light, powerful iron-hulled snag-boat is required, which can also, if necessary, be used on other streams. An estimate for such a boat is submitted by the officer in charge.

As the improvement of White River above Jacksonport has been appropriated for, it will be necessary to keep up the improvement of the lower river.

The officer in charge submits an estimate of \$194,000 for continuing the work during the next fiscal year.

Balance in Treasury of United States July, 1873	\$41,000 00
Amount in hands of officer and subject to his check	5,568 79
Amount expended during the fiscal year ending June 30, 1874	42,595 12
Amount available July 1, 1874	3,973 67
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office)	64,000 00

(See Appendix M 2.)

3. *White River, above Jacksonport, Arkansas.*—It is proposed to employ the sum appropriated in removing obstructions from the streams, such as snags, leaning trees, loose bowlders, &c. The amount available is deemed ample for the purpose, and no further appropriation is asked for unless it be decided to undertake the radical improvement of the river, with a view of obtaining an increased navigable depth. Should this be the case, at thorough survey, which will cost about \$13,000, will be necessary before any definite project can be matured.

Amount appropriated by act approved June 23, 1874	\$50,000 00
Amount available July 1, 1874	50,000 00

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Major Suter was charged with the survey of Forked Deer River, below Dyersburgh, Tennessee, provided for by act of Congress approved March 3, 1873. The report thereon was transmitted to Congress at its last session, and printed in H. R. Ex. Doc. No. 192.

(See Appendix M 3.)

IMPROVEMENT OF THE OHIO RIVER.—IMPROVEMENT OF MONONGAHELA, GREAT KANAWHA, AND WABASH RIVERS.—WATER-GAUGES ON THE MISSISSIPPI AND ITS TRIBUTARIES.

Officer in charge, Maj. W. E. Merrill, Corps of Engineers, having under his immediate orders Lieut. F. A. Mahan, Corps of Engineers.

1. *Improvement of the Ohio River.*—Of the contracts outstanding at the commencement of the fiscal year, those for dams at Chartier's Creek, Wheeling, Marietta, Buffington Island, and Cumberland Island have been completed. The work on the dike at Evansville has progressed satisfactorily. It has not, however, been considered advisable to push the work, because it was thought best to give the river time to accommodate itself gradually to its new channel. The bar at the Evansville Landing has already been reduced several feet in height, and the engineer in charge is very confident that the current thrown upon it by the dike will eventually complete its removal. No trouble is now experienced here, except at very low stages of the river. The removal of the Bacon Rock, at the mouth of the river, was begun near the close of the year, and it will probably soon cease to be an obstruction.

During the year contracts have been made for the construction of a dam to close Duck Chute, at the head of Brunot's Island; for the repair of the old dikes at French and Henderson Islands; for the building of a new dredge and dump-scoops, and for the construction of an iron hull for a new snag-boat. The Duck Chute dam was finished last season, but the water has since cut new outlets around its ends, which may require closing at some future time. The dike at French Island has been completed since the close of the fiscal year, and that at Henderson is progressing rapidly, and will be completed during the season. These are both substantial improvements. The dredge and scoops were finished last season. The snag-boat is still in process of construction.

The dredge Ohio, after completing work on the bar at Captina, where she was on the first of July, proceeded to Buffington Island and remained there until the end of the season. Work was resumed the present season by the Ohio, together with the new dredge Oswego, on the bar at the foot of Brunot's Island, and at the close of the fiscal year the removal of this bar had been nearly completed. The amount excavated during the year is as follows: By the Ohio, 260 cubic yards at Captina Island, and 40,336 cubic yards at Buffington; by both dredges, 38,038 cubic yards at Brunot's Island.

A great many obstructions have been removed from the channel this year by special contracts. Among these are the wreck of a dry-dock, near Cincinnati; the wreck of the steamer McCullough, near Madison, Ind.; the wrecks of several coal-barges at Vevay, Ind.; a large number of rocks near Mustapha Island and at the Parkersburgh Railroad bridge, and about half of the wreck of the steamer Missouri, near Evansville, Ind. Many snags and smaller wrecks have also been removed.

The officer in charge gives a description of the difficulty of improving the Lower Ohio on account of the great masses of sand and gravel that are constantly moving down in this part of the river, and concludes his report by presenting a plan for radically improving the Upper Ohio, between Pittsburgh and Wheeling. He recommends the construction of movable dams, similar to those in use in France on the Seine, the Yonne, the Marne, the Meuse, and the Moselle. Of the many systems in use in France he recommends the adoption of the "Chanoine," so-called after its inventor. By this system dams can be built which will

raise the water-surface to a height of from 12 to 14 feet above the bed of the river, but which can be thrown down in a few minutes when there is a sufficient natural supply, leaving the river entirely open to navigation. Connected with these movable dams are locks, for use when the dams are up. For the convenience of coal-fleets, he recommends locks 630 feet between gates and 75 feet wide. Extra gates in the middle will divide the lock into two shorter ones, for the benefit of packet-steam-boats.

The approximate estimate of the cost of this improvement from Pittsburgh to Wheeling is \$7,474,623. It is believed, however, that this estimate can be reduced when the detailed surveys, now in progress, are finished.

Estimate for the next fiscal year by the officer in charge.

For constructing 13 locks, between Pittsburgh and Wheeling, \$200,000 each	\$2, 300, 000
For engineering and contingencies of lock-construction, 5 per cent.	130, 000
To complete iron snag-boat	35, 000
Running expenses of two dredges	27, 000
Running expenses of snag-boat	18, 000
Building dikes on Lower Ohio	170, 000
Office expenses	20, 000
Total	3, 000, 000

Estimate for the next fiscal year as revised in this Office.

For constructing one dam and lock and one weir and gate near Pittsburgh	\$632, 000
For wing-dams, dredging, and removing snags and boulders	270, 000
Total	902, 000
Balance in Treasury of United States July 1, 1873	230, 000 00
Amount in hands of officer and subject to his check, (including \$4,620.30 percentage due on contracts not yet completed)	26, 675 96
Amount appropriated by act approved June 23, 1874	150, 000 00
Amount expended during the fiscal year ending June 30, 1874	207, 296 47
Amount available July 1, 1874, (\$199,389.49—\$4,525.65)	194, 863 84
Amount required for the fiscal year ending June 30, 1876	902, 000 00

(See Appendixes N 1 and N 2.)

Hydraulic gates and movable dams.—The board of engineer officers constituted to examine and report upon the plan of Mr. F. R. Brunot for movable hydraulic gates for chutes and locks, its applicability to the improvement of the Ohio and other rivers, and to estimate the cost of its construction, to which duty was subsequently added the general consideration of the whole subject of movable hydraulic gates and of all other proposed plans for this object, submitted their final report, which was transmitted to Congress at its last session, and printed in H. R. Ex. Doc. No. 127.

(See Appendix N 3.)

2. Improvement of Monongahela River.—The progress thus far made in the construction of the lock at Hoard's Rocks has been slow, and it is not probable that it will be finished this season, although the first and most difficult courses of the walls will be laid.

Two additional locks and dams will be required to connect this improvement with the slack-water already established on the lower river. Of these the officer in charge recommends that the United States should build the upper one, leaving the other to be built by the Monongahela Navigation Company.

The estimate submitted by the officer in charge for the next fiscal year is \$132,000 to complete the improvement in progress at Hoard's Rocks, and in addition to construct a lock at or near Cheat River Ripple.

Balance in Treasury of the United States July 1, 1873	\$90,000 00
Deduct amount expended in last fiscal year	409 14
Amount appropriated by act approved June 23, 1874	25,000 00
Amount expended during the fiscal year ending June 30, 1874	6,120 13
Amount available July 1, 1874, (\$108,470.73—\$403.84)	108,066 89
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office)	22,000 00

(See Appendix N 4.)

3. *Improvement of Great Kanawha River.*—The officer in charge reports the condition of this improvement up to August 15, at which date the work was transferred to the charge of Maj. W. P. Craighill, Corps of Engineers.

The contracts outstanding at the commencement of the fiscal year for works of improvement at Elk Shoal and at Two-mile Shoal have been satisfactorily fulfilled. The contractor has been released from his obligation to construct a dike at Cabin Creek Shoals; a careful examination of the river at this point having satisfied the engineer in charge that the proposed work would not answer the purpose for which it was intended.

A crane-boat, fitted out with a large grapple and towed by a small steamboat, worked fourteen days last fall and thirty-one days the present season in removing rocks and snags from the channel of this river. This work has given great satisfaction to the navigation interests.

As the navigation of this river will doubtless ultimately be improved by the use of locks and dams, the officer now in charge of its improvement, Major Craighill, suggests that to commence this system an appropriation of not less than \$150,000 should be made for the year ending June 30, 1876.

Should Congress, however, decide to defer entering upon that method of improvement, but to continue the unsatisfactory and insufficient process now pursued of operating upon the shoals, the sum of \$15,000 is all that will be required.

Balance in Treasury of United States July 1, 1873	\$25,000 00
Deduct amount expended in last fiscal year	352 98
Amount appropriated by act approved June 23, 1874	25,000 00
Amount expended during the fiscal year ending June 30, 1874	14,322 21
Amount available July 1, 1874, (\$35,324.81—\$800.54)	34,524 27
Amount required for the fiscal year ending June 30, 1876	150,000 00

(See Appendix N 5.)

4. *Improvement of Wabash River.*—The contracts for snagging and dredging in the lower river, and for rock-excavation and wing-dam at Coffee Island Chute, have been completed.

A contract was entered into in August, 1873, for 23,000 cubic yards of rock-excavation at the Grand Chain, thirty-eight miles from the mouth of the river. This work has been prosecuted satisfactorily thus far, and will probably be completed by December 1, 1874, as contemplated by the terms of the contract.

The officer in charge deems it indispensable that the lock and dam at Grand Rapids should be reconstructed. A survey of the river in the vicinity of these rapids, completed since the close of the fiscal year, proves this point to be the best site for the rebuilding of the lock and dam, since the lowness of the banks of both the Wabash and White Rivers renders it inexpedient to place them at White River Shoals, a site which it was hoped would be found eligible, inasmuch as a dam here

would materially improve the navigation of the White River, and at the same time obviate the necessity of further improvement of those shoals.

The estimate of the amount required for the next fiscal year includes the clearing out of the chute east of the Little Chain.

Negotiations have been commenced with the Wabash Navigation Company looking to the purchase of all their rights over the free navigation of this river, as contemplated by the proviso attached to the last appropriation for continuing this improvement. After the extinguishment of the rights of this company it is hoped that sufficient funds will be left of this latter appropriation to construct a dam to close the cut-off at New Harmony.

Balance in Treasury of United States July 1, 1873.....	\$65,000 00
Amount in hands of officer and subject to his check (including \$2,772.83 percentage due on contracts not yet completed) July 1, 1873.....	5,542 40
Amount appropriated by act approved June 23, 1874.....	25,000 00
Amount expended during the fiscal year ending June 30, 1874.....	47,558 35
Amount available July 1, 1874, (\$17,984.05 — \$2,647.80).....	45,336 25
Amount required for the fiscal year ending June 30, 1876.....	130,000 00

(See Appendix N 6.)

5. *Water-gauges on the Mississippi and its tributaries.*—One new gauge, that on the Cumberland River at Nashville, has been added to the system during the year, and the gauges at St. Louis and Cairo have been thoroughly and permanently reconstructed. The lower Louisville gauge has also been recut upon the walls of the lower canal-lock, the original graduation of this gauge having been erroneous.

It is deemed advisable to reconstruct all these gauges in a permanent manner, as rapidly as the available funds will permit, whenever the banks are sufficiently stable to warrant such a construction.

The records of the flood of 1874, collected this year, will be of great importance in the discussion of the problem of reclaiming the alluvial lands of the Mississippi. These have been placed in the hands of the commission appointed for that purpose.

Balance in Treasury of United States July 1, 1873.....	\$5,000 00
Amount in hands of officer and subject to his check.....	813 37
Amount allotted from appropriation of June 23, 1874, for examinations and surveys.....	5,000 00
Amount expended during the fiscal year ending June 30, 1874.....	5,787 16
Amount available July 1, 1874.....	5,026 21

(See Appendix N 7.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

The exploration of routes for the *extension of the Chesapeake and Ohio Canal* to the Ohio River by the north and south branches of the Potomac, directed by the act of March 3, 1873, was completed under the direction of Major Merrill, and the report thereon transmitted to Congress at its last session, and printed in H. R. Ex. Docs. Nos. 208 and 265.

(See Appendix N 8.)

The *survey of the Youghiougheny River*, Pennsylvania, also provided for by the same act, has likewise been completed under the direction of Major Merrill. For the report thereon see Appendix N 9.

IMPROVEMENT OF THE NAVIGATION AT THE FALLS OF THE OHIO RIVER, AND ENLARGEMENT OF THE LOUISVILLE AND PORTLAND CANAL.

Officer in charge, Maj. G. Weitzel, Corps of Engineers, having Capt. M. B. Adams, Corps of Engineers, under his immediate orders.

The officer in charge reports that, as stated in his last annual report, the sum of \$100,000 is still needed to complete this work as originally

designed. The delay in the execution of this portion of the work has already done harm to the unfinished parts, and will continue to do so. This sum is required to complete the rock-excavation at the head and foot of the canal, to complete the dam on the crest of the falls, and to raise the protection-wall at the upper end of the canal.

The past season was short and unpropitious for work, but all the work under contract was completed during the year, and in addition 3,100 cubic yards of rock were taken from the ledges at the head and foot of the canal by hired labor.

Balance in Treasury of United States July 1, 1873.....	\$149,989 00
Amount in hands of officer and subject to his check, (including \$20,889.17 percentage due on contracts not yet completed).....	31,501 18
Amount expended during the fiscal year ending June 30, 1874.....	154,273 78
Amount available July 1, 1874.....	27,216 40
Amount required for the fiscal year ending June 30, 1876.....	100,000 00

(See Appendix O.)

To carry out the provisions of the second and third sections of the act of Congress of May 11, 1874, "providing for the payment of the bonds of the Louisville and Portland Canal Company," Major Weitzel was instructed to confer with the president and directors of the company with a view to making the necessary arrangements for receiving and taking possession of the canal, "and all the property, real and personal, of said company as the property of the United States." The transfer was duly made and the canal delivered into the possession of the United States on the 10th June, 1874, from which date the reduction of the tolls took effect.

IMPROVEMENT OF TENNESSEE RIVER, OF CUMBERLAND RIVER BELOW NASHVILLE, TENNESSEE, AND OF THE TOMBIGBEE RIVER WITHIN THE STATE OF MISSISSIPPI.

Officer in charge, Maj. Walter McFarland, Corps of Engineers, with Capt. L. C. Overman, Corps of Engineers, under his immediate orders.

1. *Tennessee River above Chattanooga.*—Operations have been confined almost exclusively to the works which were in progress at the close of the last fiscal year, namely, Sandy Shoals, Watts's Bar, White's Creek Shoals, Half-moon Shoals, Caney Creek Shoals, between Chattanooga and Kingston; and Long Island Shoals, Seven Islands Shoals, Wilson's Island Shoals, Bogart's Shoals, and Sweetwater Shoals, between Kingston and Loudon. A small amount of work was done besides at Kelly's Shoals, just below Watts's Bar, and at Turner's Bar, just below Caney Creek Shoals, but it is not designed to attempt other improvements in this part of the river until those now in progress are finished.

At Sandy Shoals, White's Creek Shoals, and Caney Creek Shoals the work as originally designed has been completed, and the success of these improvements is gratifying. Sandy is no longer an obstruction, steamers passing regularly all through the spring and summer; but to make the lower end of the channel perfect another dam is needed.

At White's Creek Shoals there are now from three and a half to four feet water where formerly at the same season there were but eighteen inches or two feet. This, which was formerly the first place to obstruct navigation as the river fell, is now no longer an obstacle. An additional dam will, however, be required here to perfect the improvement.

At Caney Creek Shoals also the improvement is completed, except for the construction of a dam, and the gain of depth is twelve inches, which is to be increased eight more.

At the other points mentioned the improvements are in general from

one-half to two-thirds finished, as at first designed, and there is every reason to anticipate successful results from them when completed.

All the work done in this improvement during the year has been done by hired labor and is of the most substantial character. Three miles in length of these dams have been subjected to the action of last winter's heavy freshets, and yet the damage is so slight that two hundred cubic yards of stone will repair it all.

The available balance will be exhausted by the close of the calendar year.

Balance in Treasury of the United States July 1, 1873.....	\$25,000 00
Amount in hands of officer and subject to his check.....	19,527 60
Amount appropriated by act approved June 23, 1874.....	25,000 00
Amount expended during the fiscal year ending June 30, 1874.....	45,389 03
Amount available July 1, 1874.....	24,138 57
Amount required for the fiscal year ending June 30, 1876.....	65,000 00

(See Appendix P 1.)

2. *Tennessee River below Chattanooga, including the Muscle Shoals.*—The only work done in this part of the river during the year was at Ross's Towhead, Tumbling Shoals, and Colbert Shoals.

At Ross's Towhead seven hundred lineal feet of the dam at the head of the island, intended to throw the current into the left chute, have been built.

At Tumbling Shoals over three hundred cubic yards of rock have been removed from the channel.

At Colbert Shoals the work of channel excavation and construction of dams, as ordered in the original specifications, was completed, and much rock in addition was removed from the channel above Hoop-pole Reef. During the winter a part of the dam built under contract at the head of Colbert Island was carried away, making the passage of the channel dangerous. The repair of this, and the reconstruction of the other dams built by contract, are necessary to insure success in this improvement. The dams built by hired labor have withstood the winter freshets without injury, although quite as much exposed to the rush of water as that which gave way, and furnish a marked contrast to the latter in solidity and neatness of construction.

Muscle Shoals.—It was expected that the last appropriation, in addition to the balance of the one which preceded it, would have enabled the commencement of the work of repair and enlargement of the old canal between Lamb's and Campbell's ferries long ere this; but the unfortunate destruction of the result of seven months' work upon the detailed surveys and estimates made for laying out this work by the burning of the United States engineer office at Chattanooga has disappointed this expectation, and compelled the awaiting of the collection and preparation of additional data. A party is now engaged in this, and the officer in charge expects to be able to report substantial progress in this work before the close of the calendar year.

He desires to call especial attention to the inadequacy of the appropriations for this work. It will be impossible to attain satisfactory or economical results by beginning a work of this magnitude with so comparatively small a sum as is now available for it. He thinks the appropriation should not be less than \$500,000.

Balance in Treasury of United States July 1, 1873.....	\$130,000 00
Amount in hands of officer and subject to his check.....	16,233 33
Amount appropriated by act approved June 23, 1874.....	100,000 00
Amount expended during the fiscal year ending June 30, 1874.....	60,835 41
Amount available July 1, 1874.....	185,397 92
Amount required for the fiscal year ending June 30, 1876.....	750,000 00

(See Appendix P 1.)

3. *Improvement of Cumberland River below Nashville.*—The improvement of this river has, so far, been restricted to that part of it which lies below Nashville. During the past fiscal year operations have been carried on at Harpeth Shoals—the most serious obstruction below Nashville—both by contract and by hired labor. The contractor, who should have had his work finished by the 1st of January, 1873, applied for and received two extensions of time of one year each to enable him to fulfill his contract. This led to the conclusion to do the additional work, for which an appropriation had been made, by hired labor, and work by that system was begun in November, 1873, and by the close of the fiscal year twelve thousand cubic yards of stone had been quarried and moved to the river-bank in readiness for boating to the sites where the dams were to be built. Preparations were also made for the beginning of channel-excavation and the construction of the dams. In the meanwhile the contractor was carrying on his work, and at the close of the fiscal year there remained only about a quarter of his work to be done, which since then has been completed.

By the close of this calendar year it is expected that the work so far ordered for Harpeth Shoals will be completed and the appropriation exhausted.

No appropriation has yet been made for the improvement of the Cumberland River above Nashville, but a survey for the purpose of ascertaining the probable cost of this improvement was ordered by Congress, and was made in 1871. The improvement appears to be of so much importance to the welfare of the States of Tennessee and Kentucky that an appropriation of \$100,000 for the purpose is recommended.

Balance in Treasury of United States July 1, 1873.....	\$35,000 00
Amount in hands of officer and subject to his check, (including \$319.66 percentage due on contracts not yet completed).....	15,912 76
Amount expended during the fiscal year ending June 30, 1874.....	21,506 04
Amount available July 1, 1874, (excluding \$1,416.92 retained percentage).....	27,989 80
Amount required for the fiscal year ending June 30, 1876.....	175,000 00

(See Appendix P 2.)

4. *Improvement of Tombigbee River.*—Under the act of Congress approved March 3, 1873, the remainder of the appropriation of June 10, 1872, for the improvement of this river, was to be expended within the State of Mississippi. An examination of the needs of the river commerce within the limits of this State led to the conclusion that this money could be best expended above Aberdeen. A force of men, therefore, was set to work removing drifts, logs, stumps, overhanging trees, &c., which impeded the navigation of this part of the river during high water, and carried their operations from Aberdeen to a point about five miles above Cotton Gin Port, where the winter rise put an end to further operations for the season. During the present season the same method of improvement will be carried up to Barr's Ferry, on the road from Smithville, Miss., to and across the Tombigbee, which will exhaust the balance of the appropriation.

No attempt is to be made to improve the low-water navigation of this part of the river, as it would be too expensive, if not impracticable.

To complete the improvements according to the surveys which have been made will take \$46,500.

Amount in hands of officer and subject to his check.....	\$4,667 05
Amount expended during the fiscal year ending June 30, 1874.....	2,350 77
Amount available July 1, 1874.....	2,316 28
Amount required for the fiscal year ending June 30, 1876.....	46,500 00

(See Appendix P 3.)

Examination of Oostenaule River, Georgia.—The examination and sur-

vey of this river, which was made in compliance with provisions of the act of March 3, 1871, extended only to the mouth of the Coosawattee. At the request of one of the Representatives in Congress from the State of Georgia, Captain Overman was instructed, in the absence of Major McFarland, to extend this examination from Resaca to Carter's Mill.

For his report, which contains an approximate estimate for the improvement of the navigation between those two points, see Appendix P 4.

BRIDGING THE NAVIGABLE WATERS OF THE UNITED STATES.

1. *Bridge across the Genesee River at Charlotte, New York.*—An act of Congress, approved March 3, 1873, authorized "the construction of a railroad draw-bridge across the Genesee River, in Monroe County, New York," and required that the bridge "shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe."

A board of engineer officers was convened at Charlotte to examine and report upon the plans submitted by the bridge company, and its report will be found in Appendix Q 1.

2. *Bridging the channel between Lakes Huron and Erie.*—Section 3 of "An act making appropriations for the repair, preservation, and completion of certain public works on rivers and harbors, and for other purposes," approved March 3, 1873, "authorized and required" the Secretary of War "to detail from the Engineer Corps one or more engineers, whose duty it shall be to inquire into and report upon the practicability of bridging, consistently with the interests of navigation, the channel between Lake Huron and Lake Erie, at such points as may be needful for the passing of railroad-trains across said channel, and also its effect upon the navigation of the same; and, further, to inquire into the number and character of the vessels navigating said channel, and the number of trips made by each, and, if said bridging be practicable, to report what extent of span or spans and elevation above the water will be required in the construction of such bridge or bridges so as not seriously to injure the navigation of said channel."

A board of engineers was accordingly organized, by orders from the War Department, for the purpose indicated, and its report will be found in Appendix Q 2.

3. *St. Louis and Illinois bridge across the Mississippi River.*—Congress, by acts approved July 25, 1866, and July 20, 1868, (Statutes at Large, vol. 14, pp. 245, 246; vol. 15, p. 123,) authorized the St. Louis and Illinois Bridge Company to build a bridge across the Mississippi River at St. Louis, Mo.

Representations having been made by parties interested in preserving the free navigation of the river that the bridge, when completed, would materially obstruct and injuriously modify that navigation, a board of officers was convened by the War Department August 20, 1873, to examine and report upon the same.

The report of the board, together with its supplementary report, are printed in Appendix Q 3.

To comply with the request from the chairman of the Senate Committee on Commerce of April 9, 1874, an examination was made, under the direction of Colonel Macomb, of the *ponton railway-bridge across the Mississippi at Prairie du Chien*, with the view of procuring information bearing upon H. R. bill 2588, to legalize and establish said bridge.

Colonel Macomb's report will be found in Appendix Q 4.

IMPROVEMENT OF THE MOUTH OF THE MISSISSIPPI RIVER—REMOVAL OF THE RED RIVER RAFT—IMPROVEMENT OF TONE'S BAYOU AND OF CYPRESS BAYOU, RED RIVER, AND CONSTRUCTION OF DAMS AND DREDGING AT THE FOOT OF SODA LAKE—IMPROVEMENT OF CALCASIEU PASS, LOUISIANA; AND OF ENTRANCE TO GALVESTON HARBOR, AND OF RED FISH BAR, TEXAS.

Officer in charge, Capt. C. W. Howell, Corps of Engineers, having under his immediate orders the following officers of the Corps of Engineers, viz: Lieut. H. M. Adams, from July 1, 1873, to June 1, 1874; Lieut. E. A. Woodruff, from July 1, 1873, to September 30, 1873; Lieut. C. E. L. B. Davis, from July 1, 1873, to June 30, 1874; Lieut. James B. Quinn, from July 1, 1873, to June 30, 1874.

1. *Improvement of the mouth of the Mississippi River, Louisiana, at Pass à l'Outre.*—From June 30, 1873, to June 30, 1874, a channel from 17 to 20 feet deep was available each day at high tide at Pass à l'Outre.

The act of Congress, passed at its last session, giving the Secretary of War control over the use of the channel in course of improvement, though not yet enforced, has had a beneficial effect. Regulations, provided for by the act, will be established and enforced during the present year, and, it is thought, will result in preventing blockades.

In connection with the improvement of the mouth of the river, whether by canal, jetties, or dredging, numerous surveys, borings, and measurements have been made, the results of some of which have been reported from time to time as the work progressed. This field-work has not yet been completed.

During next year the dredge-boat *Essayons*, which will then have been in active service seven years, will require extensive repairs, for which \$100,000 will be required in addition to the appropriation of \$150,000 for running expenses.

Balance in Treasury of the United States July 1, 1873.....	\$85,083 00
Amount in hands of officer and subject to his check.....	7,748 55
Amount appropriated by act approved April 3, 1874.....	30,000 00
Amount appropriated by act approved June 23, 1874.....	130,000 00
Amount expended during the fiscal year ending June 30, 1874.....	117,503 40
Amount available July 1, 1874.....	135,328 15
Amount required for the fiscal year ending June 30, 1876:	
Running expenses.....	\$150,000 00
Repair of dredge.....	100,000 00
	250,000 00

(See Appendix R 1.)

2. *Removing the raft in Red River, Louisiana.*—A navigable channel through the whole length of the raft was obtained in November, 1873, since which time work has been directed to the removal of the remaining portions of the raft and to clearing the banks of the river, where necessary, to prevent the re-formation of raft and the deposit of new obstructions from caving banks.

Balance in Treasury of United States July 1, 1873.....	\$54,000 00
Amount in hands of officer and subject to his check.....	40,141 47
Amount appropriated by act approved June 23, 1874.....	50,000 00
Amount expended during the fiscal year ending June 30, 1874.....	94,068 72
Amount available July 1, 1874.....	50,072 75
Amount required for the fiscal year ending June 30, 1876.....	20,000 00

(See Appendix R 2.)

3. *Improvement of Tone's Bayou, Louisiana.*—The raft-dam reported in course of construction last year was completed and remained in place during the year, but produced no apparent useful effect; the bayou

under it deepening and permitting quite as great discharge as before its introduction. It appears that the total closure of this bayou will alone effect the end desired—that of improved navigation in Red River below Tone's Bayou, the cost of which is estimated at \$20,000.

Amount in hands of officer and subject to his check.....	\$1,007 63
Amount expended during the fiscal year ending June 30, 1874.....	989 00
Amount available July 1, 1874.....	18 63
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	20,000 00

(See Appendix R 3.)

4. *Improvement of Cypress Bayou, and construction of dams and dredging at the foot of Soda Lake, Texas and Louisiana.*—Work on the former was continued throughout the year when rendered practicable by the stage of water in the bayou, and resulted in widening, deepening, and straightening the channel from Jefferson to a point below Smithland.

Further examination was made at the foot of Soda Lake, and a plan for improvement projected, which, from its character, could not be commenced with the insufficient appropriation available.

The officer in charge submits estimates for the next fiscal year amounting to \$372,580.

Balance in Treasury of United States July 1, 1873.....	\$38,000 00
Amount in hands of officer and subject to his check.....	14,794 38
Amount expended during the fiscal year ending June 30, 1874.....	28,368 34
Amount available July 1, 1874.....	24,426 04
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	238,000 00

(See Appendix R 4.)

5. *Improvement of Calcasieu Pass, Louisiana.*—This work was completed January 13, 1874. It has benefited a large lumbering interest in Southwestern Louisiana.

Amount in hands of officer and subject to his check.....	\$9,287 51
Amount expended during the fiscal year ending June 30, 1874.....	9,210 96
Amount available July 1, 1874.....	76 55

(See Appendix R 5.)

6. *Improvement of the harbor of Galveston, Texas.*—Captain Howell submitted a report upon the results of the survey he had been directed to make for the purpose of determining and estimating the cost of some plan of improvement calculated to give an eighteen-foot entrance to this harbor.

As the method of construction proposed by him is in some degree new, and involves a large expenditure, it was deemed advisable to refer his report to a board of engineer officers for opinion thereon. These reports were transmitted to Congress at its last session, and printed in H. R. Ex. Doc. No. 136.

The appropriation of June 23, 1874, will be expended in accordance with the recommendation of this board, but only so far as to test the merits of the plan. It is hoped a result may be presented early in the next session of Congress, when estimates for the prosecution of the work will be submitted.

Amount in hands of officer and subject to his check.....	\$3,608 31
Amount appropriated by act approved June 23, 1874.....	60,000 00
Amount expended during the fiscal year ending June 30, 1874.....	3,606 54
Amount available July 1, 1874.....	60,001 77

(See Appendixes R 6 and R 7.)

7. *Improvement of Red Fish Bar, in Galveston Bay, Texas.*—This work

contemplates widening, deepening, and lengthening the cut through Red Fish Bar to meet the growing wants of commerce.

The appropriation of June 23, 1874, is not deemed sufficient to complete the work.

Amount in hands of officer and subject to his check.....	\$68 41
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	50 00
Amount available July 1, 1874.....	10,018 41
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office).....	5,000 00
(See Appendix R 8.)	

8. *Survey for the location of the terminus of the Fort St. Philip Canal under the lee of Sable Island.*—The survey of 1871 and 1872 gave the data for considering the location, except, 1st, borings and soundings along the line of probable location of the trunk of the canal; and, 2d, for inclosure of Grand Bay. These are now given by Captain Howell. (See Appendix R 9.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Captain Howell was charged with and has completed the following:

In compliance with provisions of the act of June 10, 1872—

1. *Of the Neches and Angelina Rivers, Texas.*—This was transmitted to Congress at its last session, and printed in H. R. Ex. Doc. No. 84. (See Appendix R 10.)

In compliance with the act of March 3, 1873—

2. *Pascagoula Harbor, Mississippi.*—Transmitted to Congress, and printed in H. R. Ex. Doc. No. 84. (See Appendix R 11.)

3. *Entrance of Matagorda Bay and the channel of Indianola, Texas.*—Transmitted to Congress, and printed in H. R. Ex. Doc. No. 174. (See Appendix R 12.)

4. *Bayou Lafourche, Louisiana, from Lafourche Crossing to the mouth.* (See Appendix R 13.)

5. *From the mouth of Red River down Atchafalaya River to Brashear, Louisiana.* (See Appendix R 14.)

The survey for connecting the inland waters along the margin of the Gulf of Mexico from Donaldsonville, Louisiana, to the Rio Grande, Texas, in compliance with the provisions of the act of March 3, 1873, is in progress, but owing to its great extent, not yet completed.

SHIP-CANAL TO CONNECT THE MISSISSIPPI WITH THE GULF OF MEXICO.

To comply with a resolution of the House of Representatives of March 14, 1871, Captain Howell was charged with the surveys for the location and plan of this work. His results and accompanying drawings were referred to a board of engineer officers for examination, whose report, together with that of Captain Howell, with explanatory remarks from members of the board and from this office, was transmitted to Congress at its last session, and printed in Ex. Doc. H. R. No. 220, and will be found in the appendix to this communication, as also a brief account of the application of the jetty-system to the mouth of the Rhone, recently received from Mr. E. Malézieux, engineer-in-chief in the corps of *Ponts et Chaussées*.

(See Appendixes R 15 and R 16.)

IMPROVEMENT OF THE HARBOR OF MOBILE—REMOVAL OF THE BAR AT THE ENTRANCE TO THE HARBOR OF CEDAR KEYS, FLORIDA—IMPROVEMENT OF THE NAVIGATION OF THE CHOCTAWHATCHIE, APALACHICOLA, CHATTAHOOCHEE, AND FLINT RIVERS.

Officer in charge, Capt. A. N. Damrell, Corps of Engineers.

1. *Improvement of Mobile Harbor.*—This has been continued in accordance with the plans recommended by a board of engineer-officers in 1872 and 1873. The cut through Dog River Bar has been widened through its whole length ($7\frac{1}{4}$ miles) to 120 feet, one mile of this to 150 feet, and one mile to its contemplated width of 200 feet, with 13 feet of water at mean low tide. One of the wrecks in this channel has been taken out, and the removal of another nearly completed.

The re-opening of Choctaw Bar Channel, which was commenced in January, 1874, was interrupted by an unusually high freshet on the river, which caused another partial filling up, although part of the dike across Pinto Pass, and of the jetty at Pinto Point, had been removed. Dredging in this channel was resumed again in June, and at the close of the year a cut of 120 feet in width, 13 feet deep at mean low water, through the new bar was nearly completed.

With the unexpended balance, and the appropriation of June 23, 1874, this work will be brought so near completion that an appropriation of only \$26,000 is asked for the fiscal year ending June 30, 1876.

Balance in Treasury of United States July 1, 1873	\$110,287 34
Amount in hands of officer and subject to his check, (including \$7,823.94 percentage due on contracts not yet completed)	24,186 22
Amount appropriated by act approved June 23, 1874	100,000 00
Amount expended during the fiscal year ending June 30, 1874	96,945 35
Amount available July 1, 1874	123,185 12
Amount required for the fiscal year ending June 30, 1876	26,000 00

(See Appendixes S 1 and S 2.)

2. *Improvement of the harbor of Cedar Keys, Florida.*—During the year proposals for dredging were advertised for, but the bids received were too high to secure, with the funds available, (\$7,500,) sufficient work to be of service. The bids, therefore, were not accepted, and the work is postponed until further appropriation is made, unless more reasonable offers can be received.

Balance in Treasury of United States July 1, 1873	\$7,500 00
Amount expended during the fiscal year ending June 30, 1874	44 41
Amount available July 1, 1874	7,455 59
Amount required for the fiscal year ending June 30, 1876	30,000 00

(See Appendix S 3.)

3. *Improvement of Choctawhatchee River, Florida and Alabama.*—No appropriation was made for the improvement of this river for the last fiscal year.

It is proposed to apply the appropriation of June 23, 1874, to the removal of snags and overhanging trees, beginning at the mouth of the river, and working up as far as the appropriation will allow.

In estimation of this work during fiscal year ending June, 30, 1876, \$10,000 could be profitably expended.

Amount appropriated by act approved June 23, 1874	\$5,000 00
Amount available July 1, 1874	5,000 00
Amount required for the fiscal year ending June 30, 1876	10,000 00

(See Appendix S 4.)

4. *Improvement of Apalachicola River, Florida.*—No appropriation was made for the last fiscal year. By act of June 23, 1874, \$10,000 were

appropriated for this improvement. It is proposed to apply this amount to the removal of dangerous snags, and any remaining balance to improving Moccasin Slough on this river.

Twenty thousand dollars could be profitably expended upon the improvement of this river during the next fiscal year.

Amount appropriated by act approved June 23, 1874.....	\$10,000 00
Amount available July 1, 1874	10,000 00
Amount required for the fiscal year ending June 30, 1876	20,000 00

(See Appendix S 5.)

5. *Improvement of Chattahoochee and Flint Rivers, Georgia.*—No appropriation was made for the last fiscal year. It is proposed to apply the appropriation of June 23, 1874, to the removal of wrecks and snags, and the improvement of the worst of the bars on these rivers as far as the appropriation will allow, from their mouths to Columbus on the Chattahoochee, and to Albany on the Flint.

The amount asked for continuing these improvements during the year ending June 30, 1876, could be profitably expended during that year.

Amount appropriated by act approved June 23, 1874	\$25,000 00
Amount available July 1, 1874	25,000 00
Amount required for the fiscal year ending June 30, 1876	50,000 00

(See Appendix S 6.)

ATLANTIC COAST.

IMPROVEMENT OF RIVERS AND HARBORS ON THE COAST OF SOUTH CAROLINA, GEORGIA, AND THE ATLANTIC COAST OF FLORIDA.

Officer in charge, Lieut. Col. Q. A. Gillmore, Corps of Engineers, having under his immediate orders Capt. D. P. Heap, Corps of Engineers, until December 19, 1873, First Lieut. F. A. Mahan, Corps of Engineers, from December 10, 1873, to April 24, 1874, Capt. J. W. Cuyler, Corps of Engineers, after March —, 1874, and Capt. J. C. Post, Corps of Engineers, after June 17, 1874.

1. *Improvement of ship-channel in Charleston Harbor, South Carolina.*—The original project for this improvement comprised the removal of sundry wrecks sunk during the civil war, the removal of 125 feet from the outer end of Bowman Jetty, projecting from Fort Moultrie into Beach Channel, and dredging in that channel to 15 feet at mean low water. A subsequent further shortening of the jetty was left contingent on the results secured by the first reduction of 125 feet in its length.

During the last fiscal year the depth attained over the section of 125 feet was in no place less than 11½ feet. Only 738 cubic yards of stone were removed during the year. There were also removed from the east side of the jetty, and lying close to it, the wrecks of the Stono, the Prince of Wales, and the Juno. The wreck of the monitor Keokuk was removed from the main ship-channel abreast of Morris Island. No dredging was done in Beach Channel.

During the present fiscal year it is contemplated to remove the 125 lineal feet from the outer end of Bowman Jetty, upon which work is now in progress, to a depth of 16½ feet below mean low water, and to begin and possibly finish the necessary dredging in Beach Channel to a depth of 15 feet at mean low water. A further reduction of 50 feet in the length of Bowman Jetty is indicated as desirable by the results already attained.

Balance in Treasury of United States July 1, 1873.....	\$26,700 00
Amount in hands of officer and subject to his check.....	9,142 44

Amount appropriated by act approved June 23, 1874.....	\$18,000 00
Amount expended during the fiscal year ending June 30, 1874.....	20,018 57
Amount available July 1, 1874.....	30,573 87
Amount required for the fiscal year ending June 30, 1876.....	10,000 00

(See Appendix T 1.)

2. *Improvement of Savannah Harbor, Georgia.*—During the past fiscal year the operations have consisted in deepening the channel at various points by dredging and by the removal of wrecks, as specified below. 55,369 cubic yards of material have been dredged from the shoal northeast of Fort Pulaski, which obstructs the passage of vessels from Tybee Roads into the channel nearest the fort on the north side. The channel thus secured over the shoal is 13 feet deep at mean low water, and nearly 200 feet wide. 57,688 cubic yards of materials were dredged from the long shoal abreast of Elba Island, giving a channel 13½ feet deep and 100 feet wide; 2,436 cubic yards were dredged from the shoal known as the “Wrecks,” opposite the lower end of Fig Island, this amount being the deposits that had taken place in this channel the previous year.

The wrecks of two large wooden vessels were removed from the channel near the oyster-bed beacon, opposite Fort Pulaski, where they were sunk as obstructions during the civil war. A loaded lighter was also removed from the channel near Fort Pulaski. No dredging was done opposite the lower end of Elba Island, nor opposite the upper end of Long Island, and none on Garden Bank, near the city of Savannah.

During the present fiscal year it is contemplated that the work of improvement will be carried on substantially as follows:

1. In dredging the shoal northeast of Fort Pulaski, in order to establish a channel 13½ feet deep and 150 feet wide at mean low water. It is probable that the width will exceed 150 feet.

2. In dredging at “the Wrecks,” opposite the lower end of Fig Island, so as to secure a channel 13½ feet deep and 125 feet wide at mean low water.

3. In dredging the shoal abreast of Elba Island, so as to secure at that point a channel 13½ feet deep and 125 feet wide at mean low water.

4. In dredging “Garden Bank,” opposite the lower portion of the city of Savannah, so as to establish along the city-wharves a channel 13½ feet deep and not less than 125 feet wide in that locality.

5. In removing a crib sunk during the civil war in the channel at the entrance from the Savannah River into St. Augustine Creek.

These operations will be in furtherance of the project submitted last year by the engineer in charge, in the extension of which it is intended to establish a channel of such capacity that vessels drawing 22 feet of water can ascend from Tybee Roads to Savannah City on the flood-tide, and lay at the Savannah wharves at all stages of the tide without grounding. An essential feature of the project is a deflecting-jetty or sluice-dam at “cross-tides,” four miles above the city, the object of which is to increase the volume and the velocity of the water flowing past the city on the ebb-current and augment its scouring effects upon the shoals. It is believed that the effect of this jetty or sluice-dam would be to increase the scouring effect of the ebb-current upon the shoals below, and therefore diminish the cost of dredging and of longitudinal jetties for contracting the water-way. To provide for its construction and continue the dredging, the engineer in charge recommends an appropriation of \$175,000.

Balance in Treasury of United States July 1, 1873.....	\$70,000 00
Amount in hands of officer and subject to his check.....	1,805 64

Amount appropriated by act approved June 23, 1874	\$50,000 00
Amount expended during the fiscal year ending June 30, 1874.....	71,149 55
Amount available July 1, 1874	50,656 09
Amount required for the fiscal year ending June 30, 1876.....	175,000 00

(See Appendix T 2.)

3. *Improvement of the bar at the mouth of the St. John's River, Florida.*—The operations here consist in dredging upon a bar which is constantly changing in its location and magnitude, as well as in the position, direction, and depth of the channel over it. The dredging is carried on with a centrifugal pump and suitable suction-hose, placed on board an ordinary side-wheel steamer. The improvement has always been regarded as temporary in character.

During the past fiscal year dredging was carried on between the 29th of September, 1873, and the 10th of January, 1874, resulting in the removal of 14,649 cubic yards from the bar, at an average cost of 26½ cents per cubic yard. Work was confined to the channel north of Pelican Bank, it having been found that the channel previously dredged south of that bank had shoaled to such a degree, and had become so long and crooked, that the north channel offered the best promise of useful results with the small sum available for the purpose. The work done did not result in any material improvement of the channel, the weather having been so exceptionally stormy that the increased depth attained from time to time was always filled in again by succeeding storms.

The engineer in charge doubts the wisdom of expending any more money in dredging upon this bar, and as the act approved June 23, 1874, appropriated \$10,000 for the improvement of the bar, with a distinct proviso that the money may be used in dredging out the inside passage between the St. John's River and Nassau Inlet, it is proposed to make no definite project for expending this money until the survey of this inside passage, also provided for in the same act, shall have been made. The object in either case is to improve the entrance into St. John's River.

The improvement of the inside passage, if carried far enough, will result in making Fernandina, where an excellent harbor exists, the seaport for the St. John's River. It is not now contemplated to render this passage accessible to ocean-going vessels.

Balance in Treasury of United States July 1, 1873	\$10,000 00
Deduct amount expended during last fiscal year.....	77 63
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	9,922 37
Amount available July 1, 1874.....	10,000 00
Amount required for the fiscal year ending June 30, 1876.....	15,000 00

(See Appendixes T 3 and T 4.)

IMPROVEMENT OF THE SUSQUEHANNA, NORTHEAST, ELK, CHESTER, PATAPSCO, AND WICOMICO RIVERS, AND THE HARBORS OF WORTON, QUEENSTOWN, AND CAMBRIDGE, IN MARYLAND; OF THE HARBORS OF WASHINGTON AND GEORGETOWN, D. C.; OF THE OCCOQUAN, RAPPAHANNOCK, JAMES, APPOMATTOX, ELIZABETH, AND NANSEMOND RIVERS, AND OF ACCOTINK, AQUIA, AND NOMINI CREEKS, VIRGINIA, AND OF THE ROANOKE AND CAPE FEAR RIVERS, IN NORTH CAROLINA.

Officer in charge, Maj. William P. Craighill, Corps of Engineers, who has under his immediate orders Capt. C. B. Phillips, Corps of Engineers, and Lieut. Thomas Turtle, Corps of Engineers.

1. *Improvement of Susquehanna River, near Havre de Grace, Maryland.*—The old wooden deflector has continued to stand as well as could be ex-

pected, and, according to the testimony of persons navigating the river, has been fulfilling its object of concentrating the flow of the water below the bridge and maintaining a better depth in the channel over the shoals below Havre de Grace.

It has not been possible, for want of funds, to make a survey of the locality.

The deflector was seriously injured and breached by the extraordinary ice-gorge of March, 1873. A small amount of money, as much as was available, has been expended in closing the breach, as far as practicable, by sinking old hulks, (canal-boats,) twelve in number, filled with stone. This expedient, which has proved successful, has been found cheap, owing to the nearness of the canal debouching near that point, as well as of the quarries at Port Deposit.

It is believed there can be no reasonable doubt of the advantageous influence of the work already built there, and the opinion is still held that it should be replaced by a permanent structure, which might be built for \$50,000.

Amount required for the fiscal year ending June 30, 1876 \$50,000
(See Appendix U 1.)

2. *Improvement of Northeast River, Maryland.*—Nothing has been done at this place since April, 1873, when Morris and Cumings completed their dredging. The results of their operations were the following: a channel 60 feet wide at the bottom, with a ruling depth of 5 feet at mean low water, leading from the 5-foot curve in the Northeast River to the wharf at Northeast; a basin about 120 feet long and 120 feet wide in front of the wharf; and a channel 25 feet wide, and 3 feet deep at low water, leading from the wharf to Alexander's mill.

A special report was made May 28, 1873, by the officer in charge, accompanied by a sketch which showed the condition of the channels at that time. No money has been since available for an examination of the channels. The effect of the improvement has been to increase the trade of the town and enable a steamer to run regularly between it and Baltimore, as well as sailing-vessels to aid in the trade.

It was estimated this improvement would cost \$10,000, the whole of which was appropriated in one sum and the work done for it. No more money is now required.

It is not improbable some filling may hereafter gradually take place where Stony Run empties into the channel. In time of freshets more or less sediment will be necessarily deposited from that stream.

Amount in hands of officer and subject to his check..... \$2 74
Amount expended during the fiscal year ending June 30, 1874..... 2 74

(See Appendix U 2.)

3. *Improvement of Elk River, below Elkton, Maryland.*—An examination of this river was made in January, 1873, and a preliminary report by the officer in charge, with an approximate estimate of the cost of the improvement, was submitted in reply to a call for information from the Senate Committee on Commerce, which was printed in House Ex. Doc. No. 124, March 24, 1873. See, also, pages 77 and 815 of Report of Chief of Engineers for 1873.

The estimates of the cost of the improvement now presented are based upon a more minute survey of the locality made in October, 1873. See pages 4 and 63 of House Ex. Doc. No. 84, Forty-third Congress, first session.

The improvement proposed by the officer in charge was to make, by dredging, a channel 6 feet in depth at low water, or 8 feet at high water,

from Cedar Point to Elkton, and in the Little Elk as far as Bennett's wharf. Such a channel, in both branches of the river, if 75 feet wide, will cost about \$36,000, and if but 50 feet in width, \$25,000. Cheap dikes will be required for regulating the banks, and to provide a place behind which to deposit the material dredged.

An appropriation of \$5,000 was made by the act of June 23, 1874, which will be expended at the worst place, viz, near Elkton, between the first and second guts, where the bar is nearly dry at low water. A cheap dike will be built, about 900 feet long, on the right bank of the river, opposite the mouth of the first and second guts, above and below them, at a cost, it is estimated, of about \$2,000. The remainder of the small appropriation will be spent in dredging and depositing the material behind the dike. The channel can be probably made 50 feet wide. The depth will depend on the price per cubic yard at which the work can be done.

It is deemed proper here to call special attention to the following quotation from the report of November 18, 1873: "Should it be decided by Congress to appropriate for this work, it is a case where true economy requires the whole amount to be available in one sum for continuous and prompt expenditure. It would not be expedient to commence the improvement unless at least \$20,000 were available. To this it may be added, that if the work is to be carried through with inadequate appropriations, the cost will unquestionably be more than the amount of the original estimate.

Amount appropriated by act approved June 23, 1874.....	\$5,000
Amount available July 1, 1874	5,000
Amount required for the fiscal year ending June 30, 1876.....	20,000

(See Appendix U 3.)

4. *Improvement of Worton Harbor, Maryland.*—Nothing was done in the year past, except in July, 1873, to drive a few piles to aid in the navigation of the channel, the dredging of which was completed the previous months. A channel 100 feet wide at bottom was made, connecting the wharves in use with deep water of the creek. A basin was also excavated at the head of navigation, about 150 feet long and of the same width.

The estimate for this improvement was \$12,000, which was appropriated in one sum, and the work was finished in one season. No more money is required.

Amount in hands of officer and subject to his check.....	\$222 85
Amount expended during the fiscal year ending June 30, 1874	222 85

(See Appendix U 4.)

5. *Improvement of Queenstown Harbor, Maryland.*—Nothing has been done at this place since December, 1872, when work ceased, upon the exhaustion of the appropriation, and the excavation of a channel from the town to Chester River, at the mouth of the creek. This channel was 100 feet wide at the bottom, and about 8 feet deep at low water. The work is stated by those interested to have been of great value to the trade of the place.

The estimated cost of this work was \$9,500. The appropriations were—March 3, 1871, \$5,000; June 10, 1872, \$6,000; total, \$11,000. If the whole amount of the estimate had been given in one sum, and the operations not interrupted between the expenditure of one appropriation and the grant of another, the cost would not have exceeded the estimate. No further appropriation required.

(See Appendix U 5.)

6. *Improvement of Chester River at Kent Island Narrows, Maryland.*—A survey of this locality was made in October, 1872, and a report submitted. It was estimated that to excavate a channel from Eastern Bay to Chester River, 100 feet in width, would cost \$23,000, if 7 feet deep at mean low water.

An appropriation of \$15,000 was made March 3, 1873. Some legal questions having arisen as to the right of the United States, in the progress of the work, to remove a causeway which has been standing under the authority of the State of Maryland for more than fifty years, across the channel separating Kent Island from the mainland, it was decided by the Secretary of War, after consulting the Attorney-General of the United States, to defer operations until the laws of the State relating to the subject should be repealed or properly modified. By an act approved April 11, 1874, the State of Maryland consented to the removal of the causeway, but with the provision that "before said causeway shall be cut or opened, there shall be built a bridge" with a draw of not less than 60 feet in width. In consideration of this provision, the Secretary of War decided further that the improvement would not be begun until the bridge was built, when the causeway could be removed, and the dredging of the channel may be done at the same time.

The money available may thus be most advantageously and economically expended. A further appropriation of \$5,000 was contained in the act of June 23, 1874; making a total of \$20,000.

Balance in Treasury of United States July 1, 1873.....	\$15,000
Amount appropriated by act approved June 23, 1874.....	5,000
Amount available July 1, 1874.....	20,000
Amount required for the fiscal year ending June 30, 1876.....	5,000

(See Appendix U 6.)

7. *Improvement of the entrance to the City of Baltimore.*—The object of this work has been to make a channel 24 feet deep at mean low water, for the approach to the city of Baltimore, at any ordinary stage of the tide, of vessels drawing 22½ or 23 feet, a great step forward, as twenty years ago vessels could not enter drawing more than 16 or 17 feet.

Dredging has continued during much of the year, funds being supplied partly by the United States and partly by the city of Baltimore. The contracts were completed about May 1, 1874.

During June, 1874, a thorough resurvey showed the channels to be generally in excellent condition, though requiring widening in some parts in order to completion as the necessities of the increasing commerce of this important port demand, and to give the dimensions contemplated by the present project.

The officer in charge again calls attention to the necessity for fixing and maintaining a proper port-warden's line, beyond which the building of wharves and other structures should not be permitted. This channel, like other artificial highways, requires an annual expenditure to keep it in proper condition.

For the fulfillment of the estimate of \$700,000 for the completion of the work, and to provide for the expense of annual repairs, including 1876, the sum of \$235,000 is required for year ending June 30, 1876.

Balance in Treasury of United States July 1, 1873.....	\$200,000 00
Amount in hands of officer and subject to his check.....	6,913 58
Amount appropriated by act approved June 23, 1874.....	75,000 00
Amount expended during the fiscal year ending June 30, 1874.....	206,306 07
Amount available July 1, 1874.....	75,607 51
Amount required for the fiscal year ending June 30, 1876.....	235,000 00

(See Appendix U 7.)

8. *Improvement of Cambridge Harbor, Maryland.*—On the 30th of June, 1873, Mr. Dodge, the contractor, was dredging at this place. By his operations, which were brought to a close in August, 1873, the entrance to the inner harbor was widened to 125 feet, and the sharp curve at the turn into the outer channel was eased by cutting off the projecting point on the convex side.

Some of the commercial interests are desirous to have the channel widened to an extent not contemplated by the original project, which was for a minimum improvement. The widening would doubtless be advantageous.

The estimate for this improvement was \$21,600 for a channel and basin of 8 feet depth, and \$36,000 for a depth of 10 feet at low water. Congress appropriated \$10,000 March 3, 1871, \$10,000 June 10, 1872, and \$5,000 March 3, 1873; total, \$25,000. If the whole of the estimate, \$21,600, had been appropriated in one sum, the work which cost \$25,000 would have been done for \$21,600. No further appropriation is asked unless Congress should feel inclined to make the addition to the channel referred to above.

Balance in Treasury of United States July 1, 1873	\$5,000 00
Amount expended during the fiscal year ending June 30, 1874	4,874 11

(See Appendix U 8.)

9. *Improvement of the Wicomico River, near Salisbury, Maryland.*—A survey of a portion of this river was made in 1871 and a report submitted. It was found that the improvement needed was the opening of a channel by dredging from the existing 7-foot water to the bridge, about 75 feet in width and 7 feet in depth at mean low water, at a cost of about \$20,000. The inhabitants offered and agreed to construct such bulk-heads as might be necessary to receive the material excavated from the river and give proper banks to the stream, which it was altogether proper they should do, as they would thereby be greatly improving their own property.

Congress appropriated \$5,000 June 10, 1872, which was expended in 1872 in making a channel of reduced dimensions, the width being about 25 feet. The channel thus excavated was in length about four-fifths of a mile, extending from the bridge at Salisbury through the shoalest part of the river. About one-fifth of a mile of this channel had a depth of 5 feet at mean low water, the remainder a depth of 7 feet. This was in itself a valuable improvement. The dikes, however, were not built when the dredging began, and it was promised they should be placed as soon as the dredging was completed, before the ice of winter and the freshets of spring should have degraded the banks of dredged material. The consequence (as developed by a survey made in March, 1873) was what might have been expected—a considerable filling of the dredged channel, due, in great part, to the causes mentioned above.

A new appropriation of \$5,000 was made March 3, 1873. The understanding with which the appropriations were made being that the community interested were to construct the necessary bulk-heads, it has been thought proper to defer further attempts at improvement until these structures shall have been placed. There is now a fair prospect of their being shortly built. An additional appropriation of \$5,000 was made by the act of June 23, 1874.

This channel should receive annual repairs to keep it in proper condition. For that purpose the sum of \$2,500 should be provided. The original estimate was for completion \$17,000, which was based upon the expectation of continuous and rapid work.

The appropriations have been \$5,000 June 10, 1872, expended, and \$5,000 June 23, 1874, now available. To complete the estimate and provide for filling for four years, the two sums of \$7,000 and \$10,000 are required to carry the work through 1876, or a total of \$17,000.

Balance in Treasury of United States July 1, 1873	\$5,000 00
Amount in hands of officer and subject to his check	98 14
Amount appropriated by act approved June 23, 1874	5,000 00
Amount expended during the fiscal year ending June 30, 1874	290 35
Amount available July 1, 1874	9,807 79
Amount required for the fiscal year ending June 30, 1876	17,000 00

(See Appendix U 9.)

10. *Improvement of the harbors of Washington and Georgetown, District of Columbia.*—Under authority of Congress, a commission, designated by that body, considered the subject of the further improvement of the river, and submitted a report, which was printed in Mis. Doc. No. 15, Senate, Forty-second Congress, third session.

An appropriation of \$50,000 was made March 3, 1873, which it was proposed to expend in 1873 in dredging in the Virginia or principal channel to a depth of 14 feet at low water, and along a part of the Washington front to a depth of 12 feet at low water, the main idea being so to use the money as to effect an immediate benefit to commerce, while conforming, as far as practicable, to the plan of improvement recommended by the commission.

Favorable proposals for carrying out this proposition were received in August, 1873, but, from causes unexpected and beyond control, they could not be accepted. The money is still available, and it is supposed may be expended shortly, inasmuch as the will of Congress has been indicated by special legislation contained in the appropriation bill of June 23, 1874.

The officer in charge estimates that if it should be decided by Congress to carry out the plan of improvement suggested by the commission not less than \$2,000,000 should be appropriated for the first year's work, otherwise that \$50,000 will be required to continue the dredging and remove certain dangerous rocks in the harbor of Georgetown.

Balance in Treasury of United States, July 1, 1873	\$50,000 00
Deduct amount expended in fiscal year 1872-73	730 29
Amount expended during the fiscal year ending June 30, 1874	505 76
Amount available July 1, 1874	48,760 95
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office)	50,000 00

(See Appendix U 10.)

11. *Improvement of Accotink Creek, Virginia.*—Under a contract dated September 14, 1872, operations were begun at this place October, 1872, and finished April 3, 1873. A channel about 40 feet wide at bottom, and from 2½ to 3 feet deep at low water, leading from the 2½-foot water in Accotink Bay to a point about 200 yards within the mouth proper of the Accotink Creek, and a channel about 4 feet deep and 25 feet wide from that point to the village, were completed.

No re-examination of this creek has been made for a year for want of funds, but it is understood that the work stands quite well, and that those interested in the improvement have been planting willows on the banks to prevent their degradation.

Amount in hands of officer and subject to his check	\$23 04
Amount expended during the fiscal year ending June 30, 1874	23 04
Amount required for the fiscal year ending June 30, 1876	14,000 00

(See Appendix U 11.)

12. *Improvement of Occoquan Creek, Virginia.*—At the close of the last

fiscal year Mr. A. A. Dodge was engaged in dredging a channel through Lower Mud, under his contract dated May 17, 1873. Operations were suspended August 12, after completing two cuts. A channel about 50 feet wide and 5 feet deep at mean low water through the entire width of Lower Mud was the result of the season's work.

A re-examination of the excavated channel was made in June, 1874, demonstrating the fact that very little filling had taken place during the time which had elapsed since the cessation of work.

Balance in Treasury of United States July 1, 1873	\$5,000 00
Deduct amount expended in fiscal year 1872-73	1,870 82
Amount appropriated by act approved June 23, 1874	5,000 00
Amount expended during the fiscal year ending June 30, 1874.....	2,019 29
Amount available July 1, 1874.....	6,109 89
Amount required for the fiscal year ending June 30, 1876.....	8,000 00

(See Appendix U 12.)

13. *Improvement of the Rappahannock River below Fredericksburgh, Virginia.*—In the latter part of the summer and in the autumn of 1873, some dredging was done on the Fredericksburgh Bar, the extent of the work being the removal of about 17,500 cubic yards. A portion of this matter was placed behind the dikes near Fredericksburgh, and a portion dumped down the river in places where there was little probability of its returning into the channel. The same contractor took out some logs and snags below Spotswood Bar. The object of these operations was to repair the damage done to the channel by the freshets of the spring and early summer, and to give again the depth of 8 feet at low water. A survey made in November and December, 1873, showed that the river was in a better condition for navigation than it had been for many years before. The object of the operations since 1870 had been fully attained, viz, to give 8 feet at low water as high up as Fredericksburgh, whereas previously (since the war) only 4½ were found at more than one place. This depth seems as much as the existing commerce of the river requires. To maintain it an annual appropriation of \$7,500 should be made. The officer in charge presents an estimate for giving a 10-foot channel to the town of Fredericksburgh.

Balance in Treasury of United States July 1, 1873	\$15,000 00
Deduct amount expended in fiscal year 1872-73	1,913 92
Amount appropriated by act approved June 23, 1874.....	7,000 00
Amount expended during the fiscal year ending June 30, 1874.....	7,107 19
Amount available July 1, 1874.....	12,978 89
Amount required for the fiscal year ending June 30, 1876.....	44,000 00

(See Appendix U 13.)

14. *Improvement of Aquia Creek, Virginia.*—A survey of this creek was made in 1871 under the personal supervision of Capt. C. B. Phillips, Corps of Engineers. A report was submitted in January, 1872, in which an estimate was embodied of \$18,000 for giving a channel from the 6-foot water near the mouth of the creek to the "narrows" above, about 40 feet in width at bottom and 6 feet deep at mean low water.

An appropriation of \$1,500 was made June 10, 1872, and proposals were at once invited for its expenditure in giving a channel of reduced dimensions, 20 feet in width and 4 feet in depth. The proposals received were entirely unsatisfactory, and it was decided to defer operations until an additional appropriation should be made. Congress gave \$2,000 more in the bill of March 3, 1873. The work was re-advertised, but the bids received were such that they could not be accepted. No appreciable result of any value can be attained at that place by the expenditure of \$3,500, at the lowest price at which any one has yet offered to go there.

The work should not be commenced unless the whole amount of the original estimate is available for uninterrupted operations.

Balance in Treasury of United States, July 1, 1873.....	\$2,900 00
Amount in hands of officer and subject to his check.....	466 45
Amount expended during the fiscal year ending June 30, 1874.....	137 39
Amount available July 1, 1874	3,229 06
Amount required for the fiscal year ending June 30, 1876.....	14,500 00

(See Appendix U 14.)

15. *Improvement of Nomini Creek, Virginia.*—On the 30th of June, 1873, Mr. G. H. Ferris was engaged in excavating a channel through the bar at the mouth of the creek. After completing two cuts connecting deep water in Nomini Creek with that of the bay, operations were suspended September 17. The examination made immediately after the close of the work showed a channel about 50 feet wide at bottom, with a ruling depth of 7 feet at mean low water. A re-examination of the artificial channel, made in June, 1874, disclosed the fact that the channel maintained quite well its former dimensions, although some filling has taken place.

Cost of improving creek, as per original estimate, \$20,000. Appropriated March 3, 1873, \$10,000, and June 23, 1874, \$6,000; total, \$16,000. To complete the estimate rigorously, \$4,000 are needed, but this is a case where the whole appropriation should have been made at once. Interruption of the work has caused it to be more expensive; hence \$6,000 are asked for year ending June 30, 1876.

Balance in Treasury of United States July 1, 1873.....	\$7,500 00
Deduct amount expended in fiscal year 1872-'73.....	850 46
Amount appropriated by act approved June 23, 1874.....	6,000 00
Amount expended during the fiscal year ending June 30, 1874.....	5,619 94
Amount available July 1, 1874.....	7,029 60
Amount required for the fiscal year ending June 30, 1876.....	6,000 00

(See Appendix U 15.)

16. *Improvement of the James River, Virginia.*—The operations of the year have been of the same character as of the previous year, and may be described in general by the language used in the last annual report, viz: "Removing rocks from the channel near the city of Richmond, especially at the Rockett's Reef, dredging on the bars, and depositing the material behind dikes constructed partly for that purpose and partly to rectify the banks and contract the water-way in some places where needed."

The work has been exceedingly unfortunate in the loss of Mr. N. B. Randolph, clerk and general assistant, and of Mr. W. G. Turpin, who was assistant engineer on the part of the United States and the engineer of the city in the joint operations for the improvement of the river. Both died from the effects of typhoid fever, the former in February, 1874, and the latter in June, 1874.

The channel through the reef at Rockett's has been greatly improved, being 125 feet in width and 15 feet deep at high water. Much dredging has been done on the worst bars, and a considerable length of dikes built. For details, reference is requested to the report of the officer in charge, as also for a revised estimate for giving channels respectively of 15 and 18 feet at high water, each 180 feet in width. The less depth is considered sufficient for the present wants of the trade of the river, and the operations of the year ending June 30, 1875, will be directed to the attainment of that depth, and to as great a width as the funds will allow.

A careful survey of the river was necessary, and has been made from

the ship-lock at the city as far down as Trent's Reach, including the Dutch Gap cut-off. This was necessary in order a proper determination of the changes made in the river by nature and by art in the past four years. It should be observed that the river is subject to annual freshets, sometimes violent in their effect. An annual sum of \$15,000 is deemed necessary to repair the damages caused by these freshets.

Balance in Treasury of United States July 1, 1873.....	\$115,000 00
Deduct amount expended in fiscal year 1872-'73.....	8,358 23
Amount appropriated by act approved June 23, 1874.....	50,000 00
Amount expended during the fiscal year ending June 30, 1874.....	93,596 46
Amount available July 1, 1874.....	63,045 31
Amount required for the fiscal year ending June 30, 1876.....	87,000 00

(See Appendix U. 16.)

17. *Improvement of the Appomattox River, Virginia.*—On the 30th of June, 1873, the cut through the south channel was reported completed, with a width at the bottom of about 60 feet, and a depth of about 10 feet at mean low water. The dredging of a similar channel through the Puddledock Marsh in prolongation of the south channel was in progress. A deflector 250 feet in length had been nearly completed of timber, with the object of turning a portion of the water from the old into the new channel.

At the end of June, 1874, this deflector had been securely finished; the cut through Puddledock had been completed, and the dredged channel had been brought within 3,500 yards of the city line, operations having, however, closed May 16, 1874, from want of funds. The new appropriation of \$30,000, of June 23, 1874, will enable the work to be resumed at an early day, and the minimum channel brought to the city line.

This channel of 60 feet in width is insufficient; but in its incomplete condition its use is greatly preferred by navigators to that of the old intricate and circuitous one. The officer in charge presents an estimate for increasing the width to 80 feet and giving a character of permanence by protecting the banks.

This estimate amounts to \$153,000. He calls attention also to the fact that in every stream like this, subject to copious sediment-bearing freshets, repairs will be always necessary for an artificial channel. It is estimated that \$20,000 per annum will be needed for the Appomattox for such repairs.

Balance in Treasury of United States July 1, 1873.....	\$30,000 00
Amount in hands of officer and subject to his check, (including \$286.44 percentage due on contracts not yet completed).....	8,993 33
Amount appropriated by act approved June 23, 1874.....	30,000 00
Amount expended during the fiscal year ending June 30, 1874.....	38,347 12
Amount available July 1, 1874.....	30,646 21
Amount required for the fiscal year ending June 30, 1876.....	123,000 00

(See Appendix U 17.)

Improvement of the south branch of the Elizabeth River, Virginia.—The improvement proposed was the excavation of a channel, 60 feet wide at bottom and $7\frac{1}{2}$ feet deep at mean low water, through the numerous bars and shoals between the lock of the Albemarle and Chesapeake Canal and Deep Creek, three and a half miles below; also the cutting off of one or two points where the bends in the river were very abrupt. Such a channel has been excavated nearly continuously for 5,400 yards from the lock down, and below that distance at intervals through the shoals, as far as the funds would allow. There are still two shoals, known as Nicaragua Bar and the Deep Creek Bar, through which dredging is required before the work already done will be available to the full extent.

The work has been done under two contracts. The first was with

Mr. G. H. Ferris, of Brooklyn, who removed 29,500 cubic yards of material from the river between October 13 and December 24, 1873. The second was with Mr. Marshall Parks, who, between March 4 and June 18, 1874, removed 11,855 cubic yards, of which 7,118 cubic yards were deposited on the banks of the river at various points, and 4,737 yards were thrown off lighters in coves where there was little danger of its return into the channel. The matter removed by Mr. Ferris was also dumped in coves.

The canal which is the continuation of this river is somewhat peculiar in character, having but a single lock, one of the finest in the country; and having no towing-path, steam is the only artificial motor used upon it. The communication, of which the Elizabeth River and this canal are parts, is a highly important one.

This improvement was estimated to cost \$25,000. The appropriations by Congress have been \$15,000, March 3, 1873, and \$10,000, June 23, 1874; total, \$25,000. Some of the work by contract has cost considerably more than was expected, owing to the unusual difficulties found in disposing of the material removed by the dredges, and the inability to procure and control reliable labor in that section of country, amounting at times nearly to a suspension of work. What has been stated, and the non-continuity of operations which always adds to expense, make it necessary to ask for \$5,000 for the year ending June 30, 1876.

Balance in Treasury of United States July 1, 1873.....	\$15,000 00
Deduct amount expended in fiscal year 1872-'73.....	20 00
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	14,281 73
Amount available July 1, 1874.....	10,698 27
Amount required for the fiscal year ending June 30, 1876.....	5,000 00

(See Appendix U 18.)

19. *Improvement of Nansemond River, Virginia.*—During the month of July, 1873, the snags and sunken trees in the bed of the river and overhanging trees and branches on its banks, which were obstructing navigation, were removed.

The construction of the proposed regulating and retaining dike was commenced August 6, and suspended January 13, 1874, when 2,156 lineal feet of it had been completed.

During the months of October and November all the artificial obstructions in the channel-way of the river were removed by blasting, hoisting, and dredging. They consisted of the wrecks of a schooner and a sloop, and 41 piles near Western Branch Bar, and 19 piles in Lower Blockade, about four miles from the mouth of the river. An examination of the bar at the Western Branch and its vicinity was made in April, 1874, and it was found that (owing to the contraction of the river-bed by the dike) the river had commenced cutting deeper the channel at the upstream end of the bar.

Proposals for dredging were invited, and a contract made with Messrs. Morris and Cumings June 1, 1874.

The contractors commenced operations June 5, and it is expected that they will finish their contract about July 15. A channel about 75 feet wide at bottom and 7 feet deep at mean low water will then be available.

The estimate for the improvement of this river was \$30,000. There have been appropriated by Congress \$15,000 March 3, 1873, and \$10,000 June 23, 1874; total, \$25,000, leaving \$5,000 to be appropriated to fill the estimate and complete the work.

Balance in Treasury of United States July 1, 1873.....	\$12,500 00
Amount in hands of officer and subject to his check.....	2,037 30

Amount appropriated by act approved June 23, 1874.....	\$10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	9,175 99
Amount available July 1, 1874.....	15,411 31
Amount required for the fiscal year ending June 30, 1876.....	5,000 00

(See Appendix U 19.)

20. *Improvement of the Roanoke River, below Weldon, North Carolina.*—A second snag-boat of greater capacity has been worked, in conjunction with the smaller one, over the river from Weldon to its mouth, about one hundred and thirty miles, removing snags, rafts, overhanging trees; and trees have been cut down on banks which threatened to slide, thus diminishing the probability of slides of earth, and the consequent introduction into the river of the trees growing thereon. The great prevalence of freshets has made some delay.

The cut-off known as Devil's Gut, which was lately passable by only a small boat, has been cleared, so that a steamer of moderate size can use it. The distance between Jamesville and Williamston is thus shortened six miles. In January, 1874, the snag-boats assisted in raising a tug-boat, which was sunk in the river by accident, and otherwise would probably have been a total loss, as well as become a serious detriment to the regimen of the stream. There have also been removed or so broken up that the *débris* are no longer an obstruction to navigation several vessels, viz, a light-boat at Broad Creek, a steamboat near Jamesville, and a light-boat and three schooners at Willow Bend. These were the last of the wrecks that obstructed the navigation.

Some progress has also been made in removing rocks near Weldon, but the contractor has been retarded by freshets. All his blasting is done, and he expects to complete his work in the summer of 1874. The results have been in general satisfactory, and of decided benefit to the navigation of the river, in which a large and fertile country is interested. Its products of cotton, lumber, and shingles are important.

In the estimate contained in the annual report for 1872, it was stated that the sum of \$270,000 was necessary for giving 5 feet at low water from Weldon down. The appropriations by Congress have been \$20,000 March 3, 1871; \$10,000 June 10, 1872; \$10,000 March 3, 1873; \$5,000 June 23, 1874; total, \$45,000. On the 30th of June, 1874, the sum of \$15,227.94 was available for this river. Up to this time operations have been confined to removing wrecks, snags, rafts, overhanging trees, sunken logs, and some rocks near Weldon, which, except the last, should be continued. Unless it is determined to enter systematically upon the improvement of the river in the attainment of a low-water depth of 5 feet, no appropriation is needed for year ending June 30, 1876. If that work is to be carried out, the sum of \$100,000 should be provided for the first year.

Balance in Treasury of United States July 1, 1873.....	\$20,000 00
Amount in hands of officer and subject to his check.....	4,073 41
Amount appropriated by act approved June 23, 1874.....	5,000 00
Amount expended during the fiscal year ending June 30, 1874.....	13,862 22
Amount available July 1, 1874.....	15,227 94
Amount required for the fiscal year ending June 30, 1876.....	100,000 00

(See Appendix U 20.)

21. *Improving Cape Fear River, below Wilmington, North Carolina.*—The sand has continued to accumulate around the closing work between Smith's and Zeke's Islands in a very encouraging manner. The deflecting jetty from Federal Point has been extended to a length of 500 feet. The Point has grown by the accumulation of sand along the jetty, and Zeke's Island has been also enlarged in the same way. The channel has deep-

ened over the Baldhead Bar, and an effort is to be made to assist this effort of the river to resume its old regimen by working a suction-dredge upon this bar. A cut will be made by dredging behind the Horseshoe Shoal, in the direction of the channel which existed there before the opening of New Inlet. The object of this operation is the same as that of the others mentioned above, to direct the ebb and fluvial currents from New Inlet into their former and natural course down the river directly. Efforts will also be made to increase the depth of water between New Inlet and Wilmington.

NOTE.—From a report received from the officer in charge of this work, October 8, 1874, it appears that the depth of water continues to increase in the channel over Baldhead Bar, which has become the entrance and used almost exclusively. Cargoes were, until lately, lightered below the Fort Caswell rip, or inner bar of the western channel. This is now done at Smithville, at a reduction in cost of nearly one-half. This change is due to the use of the Bulkhead Channel.

If the dredging behind the Horseshoe Shoal has successful results, and the channel is completed through the "Logs," 12 feet at low water can be taken up to Wilmington, and the use of lighters dispensed with. It is expected to accomplish this end with the present appropriation and in a few months.

Balance in Treasury of United States, July 1, 1873.....	\$100,000 00
Deduct amount expended in fiscal year 1872-73.....	9,063 32
Amount appropriated by act approved June 23, 1874.....	150,000 00
Amount expended during the fiscal year ending June 30, 1874.....	92,985 13
Amount available July 1, 1874.....	147,951 55
Amount required for the fiscal year ending June 30, 1876.....	200,000 00

(See Appendix U 21.)

SURVEYS, EXAMINATIONS, AND ESTIMATES FOR IMPROVEMENTS.

Major Craighill was charged with, and has, during the fiscal year, submitted to this Office reports upon surveys of the following localities:

1. *Elk River, Maryland, below Elkton.*—The chairman of the Committee on Commerce of the Senate of the United States having inclosed to the Secretary of War, December 19, 1872, a petition from citizens of Cecil County, Md., for an appropriation for the improvement of Elk River, in that State, and having asked for information on the subject, an examination of the river was made, and a report submitted which was printed in the report of the Chief of Engineers for 1873. See page 815.

A further survey was directed in the appropriation bill of March 3, 1873, which was made in October, 1873. For the report see pages 4 and 63 of House Document No. 84, Forty-third Congress, first session.

(See Appendix U 22.)

2. *Old-House Channel to main channel of Pamlico Sound, North Carolina.*—A survey or examination of this locality was directed in the appropriation bill of March 3, 1873. A great pressure of other duties caused it to be deferred until December, 1873. A report was submitted February 24, 1874, which was printed in H. R. Ex. Doc. No. 174, Forty-third Congress, first session.

(See Appendix U 23.)

3. *James River and Kanawha Water-line, &c.*—A board of engineers was constituted by Special Orders 17, War Department, Adjutant General's Office, January 27, 1874, to examine and report upon the James River and Kanawha Canal project. This board was organized with the addition of an eminent civil engineer of Baltimore, Mr. B. H. Latrobe,

at the request of the Hon. H. G. Davis, a member of the Senate Committee on Transportation-Routes to the Seaboard, to comply with the desire of those interested in the proposed water-line, to secure such additional evidence in regard to the cost of the entire canal, the water-supply of the summit-level, the probable time required to complete the work, and other questions involving its practicability, as would place all of these matters beyond doubt in the public mind.

The report was printed in H. R. Ex. Doc. No. 219, Forty-third Congress, first session, but some corrections and emendations have been given in the reprint in this volume.

(See Appendix U 24.)

CONSTRUCTION OF PIER AT LEWES, DELAWARE—HARBOR IMPROVEMENTS ON DELAWARE RIVER AND BAY—IMPROVEMENT OF THE NAVIGATION OF DELAWARE AND SCHUYLKILL RIVERS—OF BROAD-KILN RIVER, DELAWARE—OF SOUTH AND SHREWSBURY RIVERS—AND OF COHANSEY CREEK, NEW JERSEY.

Officer in charge, Lieut. Col. J. D. Kurtz, Corps of Engineers, with Capt. M. R. Brown, Corps of Engineers, under his immediate orders.

1. *Construction of pier near Lewes, Delaware.*—During the year the superstructure of the pier has been extended 105 feet, and all the piles have been inserted to 1,281 feet from the abutment in 15.5 feet depth of water. Nearly a corresponding number of braces have been adjusted.

The appropriation was nearly exhausted early in November, and active work suspended. A keeper has remained in charge of the buildings and other property.

It is proposed, during the present year, to place in position the thirty piles now on hand and finish the corresponding bracing and superstructure, if it can be done, and perhaps to drive a few temporary fender piles to make the pier available for vessels.

Amount required to complete the work, \$176,500.

Balance in Treasury of United States July 1, 1873.....	\$8,000 00
Amount in hands of officer and subject to his check, (including \$32,377 percentage due on contracts not yet completed).....	39,268 12
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	47,268 12
Amount available June 1, 1874.....	10,000 00
Amount required for the fiscal year ending June 30, 1876.....	176,500 00

(See Appendix V 1.)

2. *Construction and repair of Ice Harbor Piers at New Castle, Delaware.*—The remains of the old pier in the middle of the harbor and a quantity of stone accidentally dropped from vessels employed in building piers, have been removed; the wood-work of an old pier has been sheathed and protected with iron plates; and a new pier has been built up to low-water level.

It is proposed to apply the appropriation of the present fiscal year to the removal of obstructions from the harbor and the commencement of a new pier.

Amount required to complete the work, \$40,500.

Balance in Treasury of United States July 1, 1873.....	\$34,000 00
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during fiscal year ending June 30, 1874.....	22,000 15
Amount available July 1, 1874.....	14,947 65
Amount required for the fiscal year ending June 30, 1876.....	30,000 00

(See Appendix V 2.)

3. *Harbor at Marcus Hook, Pennsylvania.*—The ice-piers at this harbor were completed in 1871. Last year four iron ladders have been attached (one to each pier) to give access to the top. The piers require some repairs, which can be made during the present season from the existing appropriation.

Balance in Treasury of United States July 1, 1873.....	\$10,462 12
Amount available July 1, 1874.....	10,462 12

(See Appendix V 3.)

4. *Wilmington Harbor, Delaware.*—During the fiscal year the rock excavation above Third-street bridge was completed. Local surveys have been made at different points along the river, as far up stream as Third-street bridge, and the information derived therefrom has been added to the chart of the Christiana River in course of preparation. The removal of about 100 cubic yards of rock from the channel just below Third-street bridge is in progress under contract.

With the appropriation of June 23, 1874, it is proposed to remove about 135 cubic yards of fast rock from the channel below Third-street bridge, at the locality where work is now being done.

For the fiscal year ending June 30, 1876, it is proposed to improve the river and harbor by dredging the channel so as to afford twelve feet depth of water with the increased width of 120 feet at ordinary low tide, as follows, viz: along the channel just above the buoy depot; opposite and below Brandywine Creek; near Third street and Market street bridges. This improvement will require the removal of 53,000 cubic yards of material; 6,000 cubic yards of this amount will be loose gravel and sand, and the remainder soft mud. An appropriation of \$20,000 is required to do this.

Amount required to complete the work, \$46,000.

Balance in Treasury of United States July 1, 1873.....	\$5,000 00
Amount in hands of officer and subject to his check.....	1,895 6
Amount appropriated by act approved June 23, 1874.....	6,000 00
Amount expended during the fiscal year ending June 30, 1874.....	1,739 15
Amount available July 1, 1874.....	11,156 51
Amount required for the fiscal year ending June 30, 1876.....	20,000 00

(See Appendix V 4.)

5. *Improvement of Schuylkill River, Pennsylvania.*—During the fiscal year 97,493 cubic yards of material were removed from the bar just above Penrose-Ferry bridge; 7,500 cubic yards from the bar near Gibson's wharf; 434 cubic yards of rock from the channel near Locust-street wharf, and 172 cubic yards of rock from the channel-way at and near South-street wharf. The depths of water attained at the several localities named, at ordinary low tide, are, 20, 18, 19, and 16 feet, respectively.

The present season it is proposed to continue dredging operations at the bar above Penrose-Ferry bridge.

Next year it is proposed to complete the cut through the bar above Penrose-Ferry bridge, and to remove fast and loose rock and gravel from the channel at Gibson's wharf; also to increase the excavations so as to afford 20 feet depth of water at mean low water up to this point.

Amount required to complete the work, \$174,700.

Balance in Treasury of United States July 1, 1873.....	\$51,500 00
Amount in hands of officer and subject to his check.....	5,807 05
Amount appropriated by act approved June 23, 1874.....	20,000 00
Amount expended during the fiscal year ending June 30, 1874.....	54,975 17
Amount available July 1, 1874.....	20,000 00
Amount required for the fiscal year ending June 30, 1876.....	40,000 00

(See Appendix V 5.)

6. *Improvement of Delaware River at Fort Mifflin Bar.*—During the fiscal year 140,000 cubic yards of material have been removed. A cut 300 feet in width on the eastern portion of the bar, affording 20 feet depth of water at low water, has been excavated from the New Jersey channel on the south to the Pennsylvania channel on the north. And on the west a cut of the same extent in length has been made, with a width of 225 feet, affording the same depth of water. The locality of the improvement is eight and a half miles from the navy-yard, the width of the Delaware River at this point being about one mile.

During the present working season it is proposed to continue the dredging under the present contract, so as to increase the width of the excavation through the bar to 800 feet, with 20 feet depth of water at ordinary low tide. This will require the removal of about 70,000 cubic yards more material, which will complete the work under the existing contract.

With the appropriation of June 23, 1874, it is proposed to remove, during the present season, 70,000 cubic yards of material from the bar; next season to remove 103,000 cubic yards of material, increasing the width of the excavation to 1,200 feet, with a depth of water of 22 feet at ordinary low water.

For the next fiscal year, to continue the improvement, increasing the general width of the excavation to 1,500 feet, with side slopes and openings up and down stream of 2,000 feet. This will require an additional removal of 140,000 cubic yards of material, and a further appropriation of \$50,000.

Balance in Treasury of United States July 1, 1873.....	\$50,000 00
Amount appropriated by act approved June 23, 1874.....	50,000 00
Amount expended during the fiscal year ending June 30, 1874.....	27,189 03
Amount available July 1, 1874.....	66,951 62
Amount required for the fiscal year ending June 30, 1876.....	50,000 00

(See Appendix V 6.)

7. *Improvement of Delaware River at Horse-Shoe Shoals.*—It was recommended last year, in view of the expense of the proposed improvement, that it be deferred until it was found that, from further experience, ice-boats cannot keep the channel open at this point.

The last winter having been very mild, no special experience on this point was obtained.

Balance in Treasury of United States July 1, 1873.....	\$49,500 00
Amount in hands of officer and subject to his check.....	154 80
Amount expended during the fiscal year ending June 30, 1874.....	154 80
Amount available July 1, 1874.....	49,500 00

(See Appendix V 7.)

8. *Improvement of Delaware River between Trenton and Bordentown, New Jersey.*—Work has progressed steadily on this improvement. A channel, with a depth of 6 feet at low water and a width of 75 feet, has been carried through the shoal from deep water above to deep water below.

It is proposed next year to widen and straighten the channel to facilitate its easy passage by steamers, vessels, and boats.

Amount required to complete the work, \$40,000.

Balance in Treasury of the United States July 1, 1873.....	\$22,500 00
Amount in hands of officer and subject to his check.....	2,057 45
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	9,708 00
Amount available July 1, 1874.....	14,949 27
Amount required for the fiscal year ending June 30, 1876.....	25,000 00

(See Appendix V 8.)

9. *Improvement of Broadkiln River, Delaware.*—A channel of 5 feet depth at low water, with a minimum width of 35 feet, has been made through the shoals from Milton to Oyster-Rock Shoals, near the mouth of the river.

The appropriation having been exhausted the work has been suspended, to be resumed should Congress make a further appropriation.

Amount required to complete the work, \$70,500.

Balance in Treasury of United States July 1, 1873.....	\$10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	10,000 00
Amount required for the fiscal year ending June 30, 1876.....	30,000 00

(See Appendix V 9.)

10. *Improvement of South River, New Jersey.*—The appropriation made for this place was expended in removing the shoals existing in the canal joining the South and Raritan Rivers.

Balance in Treasury of the United States July 1, 1873.....	\$5,000 00
Amount expended during the fiscal year ending June 30, 1874.....	5,000 00

(See Appendix V 10.)

11. *Improvement of the north and south branches of Shrewsbury River, New Jersey.*—The appropriation made for this work was expended at the upper end of the Rocky-Point Channel and at other points where shoaling had occurred. A careful survey is required before further work upon the improvement of this river.

Balance in Treasury of United States July 1, 1873.....	\$5,000 00
Amount expended during the fiscal year ending June 30, 1874.....	5,000 00

(See Appendix V 11.)

12. *Improvement of Cohansey Creek, New Jersey.*—The appropriation for this work has been expended in opening a channel of 75 to 80 feet in width and 3 feet in depth at low water along the wharves of the city of Bridgeton, and for a distance of half a mile below Broad street to deeper water.

No appropriation was made for the year ending 30th June, 1875.

Amount required to complete the work, \$20,000.

Balance in Treasury of United States July 1, 1873.....	\$10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	10,000 00
Amount required for the fiscal year ending June 30, 1876.....	20,000 00

(See Appendix V 12.)

13. *Port Warden's Line, Philadelphia, Pennsylvania.*—In view of the conclusions of a board of engineer officers, constituted to examine into the subject, that the convenience of commerce as well as the improvement and maintenance of navigation imperiously demand a thorough examination of the questions involved, the report of the board was sent to the mayor of Philadelphia, with the view of inviting the attention of the government of the State to the desirableness of suitable legislation for determining these lines, and by him laid before the city councils. No action is known to have been as yet taken by them.

(See Appendix V 13.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

In compliance with provisions of the act of March 3, 1873, Lieut. Col. Kurtz was charged with and has completed the survey of "*Crow Shoals, near Cape May light, for an artificial harbor or breakwater.*" His report thereon was transmitted to Congress at its last session, and printed in H. R. Ex. Doc. No. 174.

(See Appendix V 14.)

IMPROVEMENT OF HUDSON RIVER—REMOVAL OF OBSTRUCTIONS IN EAST RIVER, INCLUDING HELL-GATE—IMPROVEMENT OF EAST CHESTER CREEK AND HARLEM RIVER, AND THE HARBORS OF PORT CHESTER AND RONDOUT, NEW YORK—PASSAIC RIVER AND THE CHANNEL BETWEEN STATEN ISLAND AND NEW JERSEY.

Officer in charge, Lieut. Col. John Newton, Corps of Engineers, who has under his immediate orders Capt. W. H. Heuer and Lieut. J. H. Willard, Corps of Engineers.

1. *Improvement of, Hudson River, New York.*—The operations during the fiscal year have comprised repairs of existing dikes and the construction of new dikes near Albany, of which there were in all 5,028½ feet in process of construction and nearly completed at the close of the year.

Balance in Treasury of United States July 1, 1873.....	\$49,500 00
Amount in hands of officer and subject to his check	11,278 89
Amount appropriated by act approved June 23, 1874	40,000 00
Amount expended during the fiscal year ending June 30, 1874.....	29,634 63
Amount available July 1, 1874.....	40,134 87
Amount required for the fiscal year ending June 30, 1876.....	102,000 00

(See Appendix W 1.)

2. *Removing obstructions in East River, including Hell-Gate.*—The tunnels and galleries at Hallett's Point have been extended to the lengths given in the following table:

Heading.		Heading.		Heading.	
	Feet.		Feet.		Feet.
No. 1	296.36	No. 2 ^b	102.04	No. 6 ^c	172.44
No. 2	185.76	No. 2 ^c	143.07	No. 6 ^d	50.60
No. 3	199.98	No. 2 ^d	48.40	No. 6 ^e	44.55
No. 4	194.53	No. 2 ^e	116.10	No. 6 ^f	27.00
No. 5	191.25	No. 3 ^a	75.88	No. 7 ^a	75.75
No. 6	224.08	No. 5 ^a	129.51	No. 10 ^a	180.85
No. 7	230.58	No. 5 ^b	66.25	No. 10 ^b	184.28
No. 8	213.92	No. 5 ^c	50.25	No. 10 ^c	130.65
No. 9	225.59	No. 6 ^a	207.58	No. 10 ^d	16.25
No. 10	257.65	No. 6 ^a , (branch) ..	15.75	No. 10 ^e	19.50
No. 2 ^a	163.27	No. 6 ^b	146.80	Galleries	2,390.20
				Total	6,780.67

From July 1, 1873, to the middle of November, when work was suspended for want of funds, the following work was done:

Lineal feet of tunnels and galleries driven.....	896.35
Cubic yards of rock removed.....	4,648.00
Lineal feet of holes drilled by Barleigh drill	43,742.00
Lineal feet of holes drilled by hand.....	618.00
Pounds of nitro-glycerine used	4,850.00
Pounds of giant powder used	506½
Pounds of black powder used	1,406.00

Operations of the steam-drilling scow, Coenties' Reef.—Work was commenced at the first of the fiscal year and continued until December 15, 1873; during this time 307 holes, amounting to 2,629 linear feet, were drilled and blasted, and 39 surface-blasts were made, 17,127 pounds of nitro-glycerine having been used.

The amount of stone grappled and removed was 2,805 cubic yards.

This does not include the amount (which is unknown) raked from the surface into the deeper water on the sides of the reef.

Balance in Treasury of United States, July 1, 1873	\$180,000 00
Less amount expended in fiscal year ending June 30, 1873.....	233 95
Amount appropriated by act approved June 23, 1874.....	225,000 00
Amount expended during the fiscal year ending June 30, 1874.....	175,843 77
Amount available July 1, 1874	228,922 28
Amount required for the fiscal year ending June 30, 1876.....	600,000 00

(See Appendix W 2.)

3. *Improvement of Harlem River, New York.*—The appropriation of June 23, 1874, will be applied during the present fiscal year to the removal of the piers of the old bridge, and of the rock off East One Hundred and Twenty-fifth street, New York.

(See Appendix W 3.)

4. *Improvement of Passaic River, New Jersey.—Belleville Bar:* The contract for this work was extended from December 31, 1873, to June 30, 1874, but owing to the many difficulties met with the work had not been completed at the close of the fiscal year. Up to that date 9,627 cubic yards of material had been removed. A great deal of bed-rock having been encountered by the contractors, a scow with machinery suitable for drilling was put to work, and the rock broken up so as to be removed by the dredging-machine.

Rutherford Park Bar: The contract for a cut through this bar 2,900 feet long and 50 feet wide on the bottom was not entirely completed at the close of the year, some little inequalities having been found which required removal. Bed-rock was also found in this section of the river, and some surface-blasts were made, and the rock broken for removal.

Balance in Treasury of United States July 1, 1873.....	\$45,000 00
Amount appropriated by act approved June 23, 1874.....	20,000 00
Amount expended during the fiscal year ending June 30, 1874.....	21,231 70
Amount available July 1, 1874.....	23,609 68
Amount required for the fiscal year ending June 30, 1876.....	54,000 00

(See Appendix W 4.)

5. *Improvement of East Chester Creek, New York.*—No work has been done during the year, except some surveys made at the entrance to the creek. A commission appointed by the State legislature to condemn and purchase certain lands, through which there was some difficulty in obtaining a right of way for the improvement of this creek, now have the matter in hand and expect shortly to report the result of their labors; until then no work can, with advantage, be undertaken.

Balance in Treasury of United States July 1, 1873.....	\$25,000 00
Amount expended during the fiscal year ending June 30, 1874.....	4,461 60
Amount available July 1, 1874.....	20,538 40
Amount required for the fiscal year ending June 30, 1876.....	35,000 00

(See Appendix W 5.)

6. *Improvement of Port Chester Harbor, New York.*—No work was done, except the finishing of some drawings of surveys.

Balance in Treasury of United States July 1, 1873.....	\$2,200 00
Amount in hands of officer and subject to his check.....	852 69
Amount expended during the fiscal year ending June 30, 1874.....	815 99
Amount available July 1, 1874	2,236 70
Amount required for the fiscal year ending June 30, 1876, to complete the removal of sunken rocks.....	60,000 00

(See Appendix W 6.)

7. *Improvement of Rondout Harbor, New York.*—During the year an extension of 1,282 feet has been added to the north dike, and on the

extremity of this extension a crib 100 feet long was sunk. Repairs were also made to that portion of the dike built the season previous, considerable damage having been occasioned by ice during the winter.

It is necessary for the success of the improvement commenced at this place that the south dike and dredging of channel-way between the dikes should be undertaken with the least possible delay.

Balance in Treasury of United States July 1, 1873.....	\$22,500 00
Amount in hands of officer and subject to his check.....	6,967 31
Amount expended during the fiscal year ending June 30, 1874.....	15,675 13
Amount available July 1, 1874.....	839 71
Amount required for the fiscal year ending June 30, 1876.....	60,000 00

(See Appendix W 7.)

8. *Improvement of channel between Staten Island and New Jersey.*—

Under appropriation of June 23, 1874, it is proposed to commence the construction of the south dike.

Amount appropriated by act approved June 23, 1874.....	\$50,000 00
Amount available July 1, 1874.....	50,000 09
Amount required for the fiscal year ending June 30, 1876.....	145,000 00

(See Appendix W 8.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

In compliance with provisions of the act of March 3, 1873, Lieutenant Colonel Newton was charged with and has completed the following. His reports thereon were transmitted to Congress at its last session, and printed in Ex. Doc. H. R. No. 174:

1. *At Harlem River, near East River, New York, for removal of rocks therefrom.* (See Appendix W 9.)

2. *At Raritan River, New Jersey.* • (See Appendix W 10.)

IMPROVEMENT OF RIVERS AND HARBORS IN THE STATES OF CONNECTICUT AND RHODE ISLAND, AND PART OF MASSACHUSETTS, AND ON THE SOUTH SHORE OF LONG ISLAND SOUND.

Officer in charge, Maj. G. K. Warren, Corps of Engineers.

1. *Hyannis Harbor, Massachusetts.*—During the past fiscal year 220 feet of the parapet at the west end, all that required rebuilding, was completed, and the slopes under water in this portion strengthened by riprap. The under-water slopes of the other parts of the breakwater need strengthening with riprap to prevent the parapet from being undermined by storms. It is estimated that \$10,000, in addition to the amount on hand, will do this and render the work secure.

From a survey made of the anchorage protected by the breakwater, it is found that this space is not filling up, and that no dredging is required. When the riprap slopes are strengthened, as recommended, it is believed that this valuable work will long remain intact.

The light-house should be removed to the east end of the breakwater.

Balance in Treasury of United States, July 1, 1873.....	\$10,000 00
Amount appropriated by act approved June 23, 1874.....	5,000 00
Amount expended during the fiscal year ending June 30, 1874.....	9,885 16
Amount available July 1, 1874.....	5,114 84
Amount required for the fiscal year ending June 30, 1876.....	10,000 00

(See Appendix X 1.)

2. *Edgartown Harbor, Massachusetts.*—The attempt to make an artificial opening through Cotamy Beach to unite Cotamy Bay directly with the ocean was in progress at the time of the last annual report.

During the season of 1873 a cut at least 60 feet wide and 6 feet deep at mean low water was carried entirely through the beach and the shoals in the bay. The work was done at periods when winds from the north and east mostly prevailed, it being deemed the most favorable time to the success of the work. Adverse winds and tides, however, caused the ocean tide to break through the barrier into the cut. The sea rushed in as long as the tide rose, but when it fell the ocean waves closed the entrance to the cut. Two attempts were afterwards made to re-open the cut, but the waves closed it again on the ocean side. The work, therefore, has failed of its object. It was carried on with energy and hopefulness, and, perhaps, with very favorable conditions of the tides and waves, might have proved successful.

The report of the engineer officer in charge of the work, here appended, treats of the questions upon which this engineering experiment arose and depends, and his experience and views regarding it.

There are reasons for doubting whether the depth on the bar at the northern entrance to Edgartown Harbor was ever dependent upon the southern one for any favorable influence, and it is proposed, with the unexpended balance of the appropriation, to determine by survey what the effect of this closure of the beach from 1869 till 1874 has been upon the northern entrance. Such injuries as may have resulted to the inner harbor of Edgartown may possibly be more easily remedied by dredging than by opening the Cotamy Beach.

No appropriation for this work was made by Congress at its last session, and none is asked till the result of the new survey is known.

Balance in Treasury of United States July 1, 1873	\$15,000 00
Amount in hands of officer and subject to his check	4,364 81
Amount expended during the fiscal year ending June 30, 1874	17,989 33
Amount available July 1, 1874	1,375 48

(See Appendix X 2.)

3. *Wareham Harbor, Massachusetts.*—The dredging for straightening, widening, and deepening this port and its entrance was carried on during the working season of 1873 as long as funds would admit. It is designed to deepen the channel to 9 feet at mean low water. It has been made 200 feet wide at Quahaug Bar; 120 feet wide at the upper bar, and widened thence upward to the wharves so as to be nowhere less than 60 feet wide.

The further improvement of this harbor will require an expenditure of about \$20,000 to make it commensurate with the interests involved; of this \$10,000 were appropriated by the act of June 23, 1874, leaving \$10,000 to be provided by future appropriation.

Balance in Treasury of United States July 1, 1873	\$15,000 00
Amount in hands of officer and subject to his check, (including \$152.09 percentage due on contracts not yet completed)	2,251 03
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874	17,157 11
Amount available July 1, 1874	10,093 92
Amount required for the fiscal year ending June 30, 1876	10,000 00

(See Appendix X 3.)

4. *Taunton River, Massachusetts.*—Under the appropriation of March 3, 1873, 224½ cubic yards of rocks and stones have been taken from the river, and 3,443 cubic yards of material dredged from the shoals. A channel 9 feet deep at mean high water has been made through Blake's, Table Rock, and Sheep-Pen Shoals, and one cut, about 25 feet wide and 600 feet long, has been made through Chabbot Rock Shoal.

A survey has been made of the obstructions near Dighton. The cost

of completing this improvement, from Taunton to Dighton, so as to give a 9-foot draught between these places at high water is estimated at \$22,000, less \$10,000 appropriated by act of June 23, 1874; the balance required, \$12,000, can be profitably expended during a single season.

Balance in Treasury of United States July 1, 1873	\$10,000 00
Amount in hands of officer and subject to his check	484 53
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874	10,387 58
Amount available July 1, 1874	10,096 95
Amount required for the fiscal year ending June 30, 1876	12,000 00

(See Appendix X 4.)

5. *Fall River Harbor, Massachusetts.*—A survey of this harbor was made last season, and a plan for its improvement, with estimate, submitted to Congress at its last session. The officer in charge estimates for the removal of bowlders and dredging a channel 100 feet wide at its narrowest part, widening at each end where it would join the main channel, to be 12 feet deep at mean low water. For removing bowlder \$11,000; for dredging, \$33,400; and for 6 dolphins to mark the channel, \$600; total, \$45,000.

The act of June 23, 1874, appropriated \$10,000 for the removal of bowlders. This will be done during the present year.

Amount appropriated by act approved June 23, 1874	\$10,000 00
Amount available July 1, 1874	10,000 00
Amount required for the fiscal year ending June 30, 1876	35,000 00

(See Appendix X 5.)

6. *Newport Harbor, Rhode Island.*—The work during the last fiscal year consisted in dredging a cut, 50 feet wide and 15 feet deep, across the shoal near Lime Rock light; in cutting off a submerged sandy point that projected into the harbor from the south end of Goat Island, so as to give a depth of 12 feet over it, and in building a jetty at right angles to the shore of Goat Island to arrest the sand and prevent the shoal point extending again.

The appropriation of June 23, 1874, will be expended in dredging within the harbor, so as to improve the anchorage and entrance to the wharves where most needed.

Balance in Treasury of United States July 1, 1873	\$8,500 00
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874	7,555 81
Amount available July 1, 1874	10,944 19
Amount required for the fiscal year ending June 30, 1876	15,000 00

(See Appendix X 6.)

7. *Pawtucket (Seekonk) River, Rhode Island.*—The channel of this river, where dredged, being in good condition at the commencement of the last fiscal year, it was determined to confine operations during the year to making a careful survey, including the bridges. This was done, and the report and map transmitted to Congress and printed. The object of doing this was to call attention to the injurious effect of the bridges upon navigation, which there seems to be no authority for the War Department to correct. Since that time another bridge across this river has been authorized by the legislature of Rhode Island, entirely independent of any control by the officers of the Engineer Corps in charge of this improvement. The officer in charge thinks that the bridge companies should be compelled to remove the obstructions they have created in the vicinity of the bridges.

He draws attention to the obstruction to navigation and to the free

flow of the tide, caused by the three bridges on the Pawtucket, and desires to be informed whether there is not a legal remedy to compel the bridge companies to restore the water-way to a proper natural width, and to control the bridging of the river in the interests of commerce. One of these bridges, at present a serious obstruction to commerce, is about to be rebuilt, and its future location and plan should be subject to the control of the United States.

It is proposed to expend the funds on hand the present year in dredging at the parts where it will be most beneficial. No further appropriation is recommended.

Balance in Treasury of United States July 1, 1873.....	\$10,000 00
Amount expended during the fiscal year ending June 30, 1874	6 96 55
Amount available July 1, 1874	9,313 45

(See Appendix X 7.)

8. *Providence River, Rhode Island.*—The appropriation of March 3, 1873, was expended in removing the point of Long Bed, and in taking out the remains of an old pile-dolphin found in the channel.

The channel here is now 800 feet wide, the dredging having increased it to this width from that of 400 feet.

No further appropriation is required.

Balance in Treasury of United States July 1, 1873.....	\$10,000 00
Amount in hands of officer and subject to his check.....	178 24
Amount expended during the fiscal year ending June 30, 1874	10,101 26
Amount available July 1, 1874	76 98

(See Appendix X 8.)

9. *Wickford Harbor, Rhode Island.*—The work during the past year consisted in dredging so as to lessen the sharpness of the turn in the channel, and in removing a rock from the channel.

With the appropriation of June 23, 1874, further dredging will be done and some rocks removed.

No further improvement is required here for the present, except to build a beacon on James Ledge.

Balance in Treasury of United States July 1, 1873.....	\$5,000
Amount appropriated by act approved June 23, 1874	5,000
Amount expended during the fiscal year ending June 30, 1874.....	5,000
Amount available July 1, 1874	5,000

(See Appendix X 9.)

10. *Block Island, Rhode Island.*—The main breakwater was extended about 330 feet during the fiscal year, with a considerably less cross-section than that of the part before built, in order to obtain shelter sooner than could be done by carrying out the full dimensions at once. It is expected to increase the thickness of this portion during the present year, to bring it to the proper proportions for permanence. This, with an extension of about 100 feet to where the water is 15 feet depth, will exhaust the appropriation of June 23, 1874.

During the past year 446 tons of bowlders were removed from the bottom within the protected area, and deposited in the breakwater. There is a sufficient amount left of the former appropriation to free all this sheltered anchorage, where the depth is as great as 6 feet, and this will be done. There will also be an improvement made for the discharge of cargoes in the inner basin.

An estimate of \$60,000 is submitted for the next season's operations, so that in one year there can be put in a detached piece of breakwater north of the harbor to protect it from northeast storms, which are the only ones that now cause any trouble. It is necessary to do this all at

once, so that it may not, in an incomplete state, be a dangerous obstruction.

This breakwater has been an improvement, the beneficial effect of which is most apparent.

Balance in Treasury of United States July 1, 1873.....	\$60,000 00
Amount in hands of officer and subject to his check, (including \$857.32 percentage due on contracts not yet completed).....	6,551 55
Amount appropriated by act approved June 23, 1874.....	20,000 00
Amount expended during the fiscal year ending June 30, 1874.....	50,572 30
Amount available July 1, 1874.....	35,979 25
Amount required for the fiscal year ending June 30, 1876.....	60,000 00

(See Appendix X 10.)

11. *Pawcatuck River, Rhode Island and Connecticut.*—The appropriation of March 3, 1873, was expended in dredging during last season. A channel-way 40 feet wide and from 5 to 5½ feet deep at mean low water is now finished to the wharves in Westerly. It is designed to make the channel 75 feet wide in its narrowest part, and 5½ feet deep at mean low water. The estimate for completing this is \$21,000. The act of June 23, 1874, appropriated \$10,000 for this work, leaving \$11,000 to be appropriated.

The beneficial effects of this improvement are shown in the diminished cost in freights to Westerly.

Balance in Treasury of United States July 1, 1873.....	\$10,000 00
Amount in hands of officer and subject to his check, (including \$900.17 percentage due on contracts not yet completed).....	1,858 42
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	11,668 72
Amount available July 1, 1874.....	10,189 70
Amount required for the fiscal year ending June 30, 1876.....	11,000 00

(See Appendix X 11.)

12. *Stonington Harbor, Connecticut.*—Operations during the past fiscal year were confined to dredging in the harbor between the breakwater and the steamboat-dock, to make this space available as an anchorage-ground.

The work already done has given a depth of 12 feet from the channel as near to the wharves as it is thought advisable to carry this work. It is proposed, with the appropriation of June 23, 1874, and with what remains from the previous one, to dredge off the upper end of Penguin Shoal.

The engineer in charge of the improvement during the past fiscal year recommends that, if any further improvements be made here, a breakwater should be built on the outer part of Penguin Shoal, for which he submits a plan, with an estimate of \$96,000.

Balance in Treasury of United States July 1, 1873.....	\$25,000 00
Amount appropriated by act approved June 23, 1874.....	20,000 00
Amount expended during the fiscal year ending June 30, 1874.....	21,047 22
Amount available July 1, 1874.....	23,952 78
Amount required for the fiscal year ending June 30, 1876.....	96,000 00

(See Appendix X 12.)

13. *Connecticut River below Hartford, and Saybrook Bar, Connecticut.*—The work done during the fiscal year left a channel from 50 to 70 feet wide and 9½ feet deep at low water over the bars at Hartford, Pratt's Ferry, and South Glastenbury; the jetty at Saybrook Bar was carried out to a total length of 1,600 feet. With the appropriation of June 23, 1874, it is designed to dredge in these channels, wherever examinations

show that they have shoaled during the winter, and to continue the jetty as far as the remaining funds will allow.

Balance in Treasury of United States July 1, 1873	\$45,000 00
Amount in hands of officer and subject to his check, (including \$281.20 percentage due on contracts not yet completed).....	1,730 43
Amount appropriated by act approved June 23, 1874	20,000 00
Amount expended during the fiscal year ending June 30, 1874.....	42,713 37
Amount available July 1, 1874	24,017 06
Amount required for the fiscal year ending June 30, 1876	80,000 00

(See Appendix X 13.)

14. *Connecticut River, above Hartford, Connecticut, and below Holyoke, Massachusetts.*—A survey and map of the whole of this portion of the river have been completed. A channel was dredged through Barber's Landing Bar, about three and one-third miles above Holyoke, which was the only improvement needed. The act making the appropriation of 1872 limited its application to the part above the foot of Enfield Falls. About half of this has been spent in surveys and investigations. There is no place found above the falls where improvement is now required, and the balance is too small to accomplish anything at the falls. As the wing-dams built between Hartford and the falls have been found beneficial, it is proposed to continue this work, where needed, with the funds on hand.

Connecticut River from Enfield Falls to Holyoke.

Balance in Treasury of United States July 1, 1873	\$25,000 00
Amount expended during the fiscal year ending June 30, 1874.....	12,391 45
Amount available July 1, 1874	12,608 55

Connecticut River above Hartford and below Holyoke.

Balance in Treasury of United States July 1, 1873	\$25,000 00
Amount in hands of officer and subject to his check.....	1,606 65
Amount expended during the fiscal year ending June 30, 1874.....	4,834 34
Amount available July 1, 1874.....	21,772 31

(See Appendix X 14.)

15. *New Haven Harbor, Connecticut.*—During the past fiscal year the dredging consisted in completing a 15-foot channel to 200 feet width through the bar between Fort Hale and the light-house, and in widening the 13-foot channel, from Long Wharf to Belle Dock, to 115 feet. A beginning was made upon the removal of Ludington Rock, but before work was fairly under way the favorable season closed.

The remainder of the appropriation for the fiscal year ending June 30, 1874, will be expended in prosecution of the removal of Luddington Rock. Under the existing contract the rock must all be removed before any money is paid.

Balance in Treasury of United States July 1, 1873	\$40,000 00
Deduct amount expended in fiscal year 1872-'73	854 11
Amount expended during the fiscal year ending June 30, 1874.....	18,252 58
Amount available July 1, 1874	20,893 31

(See Appendix X 15.)

16. *Milford Harbor, Connecticut.*—A survey made in 1872 showed that prominent among the causes of the formation of a bar in the upper part of the harbor was the erosion of the east bank, caused by the action of southerly storms. The object of the work during the present year will be to prevent further action of this kind by constructing jetties between high and low water, at intervals of 100 feet, along the shore.

Amount appropriated by act of June 23, 1874.....	\$5,000 00
Amount available July 1, 1874.....	5,000 00
Amount required for the fiscal year ending June 30, 1876.....	13,000 00

(See Appendix X 16.)

17. *Housatonic River, Connecticut.*—During the last fiscal year the dredging was confined to the removal of an obstruction, “the ballast,” near the mouth, and to dredging at Mill Bar, Drew’s Bar, Crofut’s Bar, and Two-mile Island Bar, at all of which places a depth of 7 feet at mean low water was made. The width of this channel varies from 40 to 150 feet, and needs widening in the narrower portions. No work was done at the bar at the mouth. A resurvey was made of portions of the river, to ascertain changes and results of operations, and to make connected maps.

The average mean rise of the tide being 5 feet, no greater depth than 7 feet at mean low water is required, which has been gained at all points except the bar at the mouth, where the depth is only 5 feet. The improvement of this is such a serious matter that it is not at present recommended. The appropriation for the fiscal year ending June 30, 1875, will be used in widening the channel at the narrow places already improved, and in removing shoals which may have reformed.

Balance in Treasury of United States July 1, 1873.....	\$10,000 00
Amount in hands of officer subject to his check, (including \$104.24 percentage due on contracts not yet completed).....	3,396 54
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	13,169 61
Amount available July 1, 1874.....	10,226 93
Amount required for the fiscal year ending June 30, 1876.....	5,000 00

(See Appendix X 17.)

18. *Bridgeport Harbor, Connecticut.*—The work during the past year has been confined almost wholly to dredging, the requisite protection of the breakwater for immediate wants having previously been secured. The mean rise of the tide here is 665 feet, and the least depth of the improved channel is 9 feet at mean low water.

On the outer bar the channel is 10 feet deep, 150 feet wide. At the inner bar it is 400 feet wide, with a depth of 9 feet. Thence upward to the bridge the channel has been much widened and straightened, and a wreck removed. This harbor now affords many facilities to commerce.

The means on hand will be used to widen and straighten the channel.

An estimate of \$20,000 is made to provide for a probable extension of the breakwater, or additional dredging, which the action of storms may render necessary.

Balance in Treasury of United States July 1, 1873.....	\$30,000 00
Amount in hands of officer and subject to his check, (including \$1,747.86 percentage due on contracts not yet completed).....	7,120 59
Amount appropriated by act approved June 23, 1874.....	20,000 00
Amount expended during the fiscal year ending June 30, 1874.....	33,197 61
Amount available July 1, 1874.....	23,922 98
Amount required for the fiscal year ending June 30, 1876.....	20,000 00

(See Appendix X 18.)

19. *Norwalk River, Connecticut.*—The work of dredging in progress at the date of the last annual report under the appropriation of March 3, 1873, was continued until the available funds were exhausted. The channel, 60 feet wide and 6 feet deep at mean low water, dredged in 1872, has been continued to within 600 feet of the Norwalk docks. With the appropriation of June 23, 1874, it is proposed to complete this channel, and, if any funds remain, to excavate the channel both above and below the Washington bridge to a depth of 6 feet and width of 80 feet.

To realize the full effect of the work done and to carry out the entire project based upon the survey of 1871, requires the completion of a channel 60 feet wide and 6 feet deep at mean low water from Gregory’s

Point to Norwalk. The estimated cost of this is \$10,000, which amount is recommended for the fiscal year ending June 30, 1876.

Balance in Treasury of United States July 1, 1873.....	\$5,000 00
Amount in hands of officer and subject to his check.....	5,006 41
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	10,006 41
Amount available July 1, 1874.....	10,000 00
Amount required for the fiscal year ending June 30, 1876.....	10,000 00

(See Appendix X 19.)

20. *Port Jefferson Harbor, Long Island, New York.*—On account of the small amount of funds available, no work was done the past fiscal year. At its close a survey was made, which shows that what has been done has so far answered its purpose, and that the entrance has now become so permanent in its conditions that the time when dredging could be made with reasonable certainty of the channel not being filled up has now arrived.

An appropriation of \$35,000 is recommended for continuing the work.

Amount in hands of officer and subject to his check.....	\$1,713 95
Amount expended during the fiscal year ending June 30, 1874.....	204 01
Amount available July 1, 1874.....	1,509 94
Amount required for the fiscal year ending June 30, 1876.....	35,000 00

(See Appendix X 20.)

21. *Peconic River, Long Island, New York.*—During the past fiscal year the channel was continued for a distance of 8,520 feet up the river, making it 55 feet wide and 6 feet deep at mean low water. This left a length of about 2,500 feet improved, which has since been worked upon under an appropriation of the State of New York.

No further improvement on the part of the United States is called for at present.

Balance in Treasury of the United States July 1, 1873.....	\$10,000 00
Amount in hands of officer and subject to his check, (including \$522.50 percentage due on contracts not yet completed).....	4,471 68
Amount expended during the fiscal year ending June 30, 1874.....	14,061 24
Amount available July 1, 1874.....	410 44

(See Appendix X 21.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Major Warren was charged with, and has completed, the following, directed to be made by act of March 3, 1873, viz:

2. *At Wood's Hole, in Buzzard's Bay, Massachusetts, for removal of rocks therefrom.*

2. *Harbor at Fall River, Massachusetts, for removal of rocks therefrom.*

3. *At the outlet of Point Judith Lake, Rhode Island.*

His reports upon these were duly transmitted to Congress at its last session, and printed in H. R. Ex. Doc. No. 84.

(See Appendixes X 22, X 23, and X 24.)

IMPROVEMENT OF RIVERS AND HARBORS IN THE STATES OF MAINE AND NEW HAMPSHIRE.

Officer in charge, Lieut. Col. George Thom, Corps of Engineers, who had under his orders Capt. William S. Stanton, Corps of Engineers, in the prosecution of works in Massachusetts. The harbor-works in Massachusetts were assigned June 11, 1874, to Lieut. Col. J. G. Foster, Corps of Engineers. Subsequently, upon the death of this officer, Lieutenant-Colonel Thom was directed to resume their charge.

1. *Saint Croix River, above the "Ledge," Maine.*—The following appropriations have been made for the improvement of this river:

By act of Congress approved March 2, 1867	\$15, 000
By act of Congress approved March 3, 1873	10, 000
By act of Congress approved June 23, 1874	10, 000
Total	35, 000

The act of March 2, 1867, contains a proviso that "the province of New Brunswick contribute and pay to the proper disbursing officer a like sum for said purpose; said payment being made on condition that in no event shall the province of New Brunswick be called upon for more than half the sum actually expended for said purpose." In July, 1873, information was received from the minister of public works of the Dominion of Canada that the sum of \$25,000 had been appropriated by Parliament, and the work was accordingly intrusted to Lieut. Col. George Thom, Corps of Engineers, and Henry F. Perley, esq., engineer department of public works. An accurate survey was made of this river from the "Ledge" up to the bridge at the head of navigation, a distance of about five miles, with a view to deciding upon a definite plan for its improvement by the two governments. But information was subsequently received from the minister of public works that he would not consent to the expenditure of any portion of the sum which had been voted by his government until thoroughly satisfied that there would be no further deposition of slabs and sawdust from the mills on the St. Croix, because if the river were cleared out as proposed, there is no guarantee that it would remain in a state of efficiency, but would soon be closed again and require further expenditure. Similar views were expressed by the United States engineer in charge of this work in his first report on this subject, as well as in his reports upon other works, to which attention was asked in order that some general law might be passed to protect from injury and obstruction this and other navigable waters, for the improvement of which Congress has made or may make appropriations. Under the existing circumstances it will be necessary to postpone the improvement of this river until some guarantee can be had as to its future protection and preservation.

Balance in Treasury of United States July 1, 1873	\$24, 000 00
Amount in hands of officer and subject to his check	983 25
Amount appropriated by act approved June 23, 1874	10, 000 00
Amount expended during the fiscal year ending June 30, 1874	797 67
Amount available July 1, 1874	34, 185 58

(See Appendix Y 1.)

2. *Machias River, Maine.*—The improvement projected for this river consists in the removal of a very large and dangerous ledge, (known as Middle Rock,) which lies in mid-channel near the wharves of Machias; and in the enlargement of the channel through the several shoals formed of slabs, edgings, &c., so as to obtain a channel 150 feet wide and 6 feet deep at mean low water (or 19.3 feet at ordinary high water) from deep water, near the East Machias bridge, up to the wharves at Machias, a distance of three miles. This work requires about 1,500 cubic yards of rock excavation, and 50,000 cubic yards of dredging, the cost of which is estimated at \$48,000.

A contract was made June 18, 1873, for the removal of Middle Rock, and on the 28th of July, 1874, it was completed down to an average depth of about one-half a foot below the plane of mean low water.

The appropriation of June 23, 1874, will be applied to the deepening of the channel through the middle ground.

Balance in Treasury of United States July 1, 1873.....	\$11,000 00
Amount in hands of officer and subject to his check.....	950 84
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	5,504 44
Amount available July 1, 1874.....	14,758 90
Amount required for the fiscal year ending June 30, 1876	26,000 00

(See Appendix Y 2.)

3. *Narraguagus River, Maine.*—The navigation of this river has hitherto been much obstructed by several ledges and a very large number of sunken bowlders, and by bars composed of slabs, edgings, and sawdust. The following appropriations have been made for its improvement:

By act of March 3, 1871.....	\$12,000
By act of June 10, 1872	10,000
Total.....	22,000

During the past year the following work has been done: 1,335 tons of sunken ledge and bowlders removed from the falls, from Freeman's Point, and between there and the bridge at Cherryfield; about 5,000 cubic yards of slabs, edgings, &c., removed at and below Freeman's Point, and between there and Cherryfield bridge, making altogether a total of over 3,000 cubic yards of sunken ledges and bowlders, and 7,000 cubic yards of slabs, edgings, and sawdust, removed from the channel of the river.

In addition to this work, a large wrought-iron (9-inch) spindle with day-mark has been placed upon Half-tide Rock at Millbridge. Two spar-buoys have also been placed on the ledges on each side of the narrow channel near Small's Point, and two more on the ledges below the falls. This completes all the work that has been projected for the improvement of this river.

By this work the navigation of this river has been greatly improved in its safety and depth of channel; so much so that coasting-vessels of light draught, with center-boards, have of late, for the first time, been running to and from the wharves at Cherryfield, taking out lumber and other products of the country, and returning with coal and general merchandise, without transshipment, as formerly, at Millbridge.

Balance in Treasury of United States July 1, 1873	\$3,000 00
Amount in hands of officer and subject to his check	1,763 89
Amount expended during the fiscal year ending June 30, 1874.....	4,763 89

(See Appendix Y 3.)

4. *Sullivan River and Sullivan Falls, Maine.*—This river is navigable from its mouth up to Franklin, a distance of about nine and a half miles. Hitherto it has been seriously obstructed, and its navigation endangered by Hatcher's Rock and numerous other sunken ledges in the falls, and by the stone foundations of several bridge-piers one mile above the falls. For the improvement of this river and the falls the following appropriations have been made:

By act of March 3, 1871.....	\$10,000
By act of June 10, 1872.....	25,000
Total	35,000

During the past fiscal year the work on Hatcher's Rock and the point of ledge near it in the falls has been completed; a very accurate survey of the falls has been made; and a contract made for the removal of three newly discovered sunken ledges. The progress that has been made in the improvement of this river and falls up to the 1st of July, 1874, therefore consists—

1. In the removal of Hatcher's Rock and the point of ledge near it, together with 85 cubic yards of sunken ledge in the falls, to a depth of 7 feet below mean low water, or $11\frac{1}{2}$ feet at mean high water.

2. The removal to a depth of 10 feet below mean low water of three bridge-piers above the falls, affording a channel for that depth 350 feet in width.

3. Wrought-iron spindles with day-marks have been placed upon Half-tide Rock and Low-water Rock, about one mile below Sullivan, and a spar-buoy on Crabtree Ledge, near the mouth of the river. Two spar-buoys have also been placed to mark the new channel opened through the bridge-piers.

In addition to the foregoing work, a contract has been made for the removal of all the remaining dangerous sunken ledges from the channel of the falls to a depth of 7 feet at mean low water.

This comprises all the work that is projected for the improvement of this river and the falls, for doing which the available funds are sufficient.

Balance in Treasury of United States July 1, 1873.....	\$16,000 00
Amount in hands of officer and subject to his check, (including \$1,200 percentage on contracts not yet completed).....	1,852 03
Amount expended during the fiscal year ending June 30, 1874.....	13,921 30
Amount available July 1, 1874	3,930 73

(See Appendix Y 4.)

5. *Penobscot River, Maine.*—The navigation of this river is much obstructed by shoals and sunken rocks, between Bangor and Crosby's Narrows, about three and a half miles below. The shoals below Bangor are chiefly formed of slabs, edgings, and sawdust thrown into the river from the mills above; while the principal shoal in the harbor of Bangor is composed of gravel, sand, and boulders. The sunken rocks are all in the harbor of Bangor, and are known as Independence Rock, Steamboat Wharf Ledge, ledge off Dole's planing-mills wharf, Green's Pier Ledge, &c.

The work projected for the improvement of this river consists—

1. In enlarging and straightening its channel through the several bars and shoals, so as to have a width of not less than 200 feet and a depth of 12 feet below the plane of low water (or 25 feet at high water) in the lowest stages of the river; and

2. In breaking up and removing all the sunken rocks down to a level of the general bed of the river, so as to have not less than 7 feet of water over them at low water in the lowest stages of the river, which will give about 9 feet in its ordinary summer stage; except from Green's Pier Ledge, which is to have but 5 feet over it at mean low water.

The progress made in this work up to July 1, 1874, is as follows, viz: broken up and removed from Independence Rock, about 880 tons; from Steamboat Wharf Ledge, about 1,000 tons; from Green's Pier (outer) Ledge, about 115 tons; and Gulliver's Rock (containing about 80 tons) wholly removed; altogether about 1,000 cubic yards of sunken rocks, which were removed prior to July 1, 1872. On the 26th of August, 1872, a contract was made for removing the remaining portions of these ledges. Under this contract the removal of Steamboat-wharf Ledge was completed in September, 1873, to the depth called for; the removal of the ledge off Dole's planing-mill wharf and of Independence Rock is nearly completed, with a probability that both will be completed before the close of the present season. A contract was also made on the 21st of June, 1873, for the removal of the remaining ledge at Green's Pier. Contracts have thus been made for removing all the sunken ledges; some of which have already been removed, and the remainder

probably will be before the close of the present season, with the exception of the ledge at Green's Pier, on which some progress is soon to be made with a probability of its completion early next season. Contracts have also been made for the removal, to the extent contemplated, of all the shoals composed of slabs, edgings, and sawdust, so that the only work that now remains to be provided for, in order to complete all the improvements projected for this river, consists in the excavation of a channel through the gravel-bar in the harbor of Bangor, so as to have a depth of 12 feet of water in the lowest stages of the river. The appropriation of June 23, 1874, will be applied to the improvement of this bar, to complete which \$50,000 additional will be required.

The officer in charge again states that the throwing of sawdust into this river is still continued to a very great extent, and to the serious detriment of its navigation.

In view of this and that several other navigable rivers in his district, now being improved by the Government, are also being injured and obstructed by the throwing in of slabs, edgings, &c.; by the building of piers and bridge-draws in improper places and otherwise, he suggests the passage of some general law for the protection and preservation of navigable waters for the improvement of which Congress has made or may make appropriations.

Balance in Treasury of United States July 1, 1873.....	\$60,000 00
Amount in hands of officer and subject to his check.....	12,810 00
Amount appropriated by act approved June 30, 1874.....	20,000 00
Amount expended during the fiscal year ending June 30, 1874.....	9,795 08
Amount available July 1, 1874.....	81,814 99
Amount required for the fiscal year ending June 30, 1876.....	50,000 00

(See Appendix Y 5.)

6. *Camden Harbor, Maine.*—The work for the improvement of this harbor consists in the opening of a channel to a width of 100 feet and to a depth of 7 feet below the plane of mean low water (or 16½ feet at mean high water) up to the head of the wharves on the eastern side of the harbor, and a second channel to a width of 60 feet and a depth of 4 feet at mean low water up to the head of the wharves on the western side of the harbor, and in regulating the entrance into those channels. The estimated cost of this work was \$33,000. By act of March 3, 1873, the sum of \$10,000 was appropriated for it, which was applied to opening the eastern channel to a depth of not less than 7 feet at mean low water for a width of not less than 50 feet.

This was completed in October, 1873. The amount appropriated by act June 23, 1874, will be applied to opening the western channel for a width of 50 feet and to regulating the entrance to it from below.

Balance in Treasury of United States July 1, 1873.....	\$9,000 00
Amount in hands of officer and subject to his check.....	948 63
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	9,948 63
Amount available July 1, 1874.....	10,000 00
Amount required for the fiscal year ending June 30, 1876.....	13,000 00

(See Appendix Y 6.)

7. *Kennebec River, Maine.*—All the projected improvements of this river above Richmond were completed prior to June 30, 1873, as described in the annual report for the fiscal year ending that date, and a safe and unobstructed channel, not less than 100 feet in width and 10 feet in depth at mean low water, (or 15½ feet at mean high water,) in its low summer-stages, completed from Richmond up to Gardiner, and thence to Augusta, a channel 100 feet in width and not less than 6½ feet

in depth at low water, (or 11 feet at high water,) in its lowest summer-stages. The work that remains to be done for completing all the projected improvements of this river consists in the removal of several dangerous sunken ledges lying in its channel in "the narrows" below Richmond. Contracts have been made for the removal of all these, with the exception of Dry Rock, and it is probable that their removal will be completed before the close of the present season. Dry Rock contains, down to the 12-foot plane below mean low water, about 1,850 cubic yards, the removal of which it is estimated will cost about \$40,500. Of the funds heretofore appropriated there will be available for removing Dry Rock the sum of about \$14,500, but it is not deemed advisable to expend any portion of this sum upon that work until the additional sum required for its completion is appropriated.

Balance in Treasury of United States July 1, 1873	\$14,000 00
Amount in hands of officer and subject to his check	1,482 80
Amount appropriated by act approved June 23, 1874	12,000 00
Amount expended during the fiscal year ending June 30, 1874	9,495 05
Amount available July 1, 1874	17,987 75
Amount required for the fiscal year ending June 30, 1876	26,000 00

(See Appendix Y 7.)

8. *Portland Harbor, Maine.*—On the 1st of July, 1873, the following work had been done for the improvement of this harbor, viz:

1. The capping of the breakwater extended for a length of 733½ feet, leaving 217 linear feet more to be done;
2. A channel dredged through the Middle Ground Bar to a width of 500 feet and to a depth of 21 to 22 feet at mean low water, or 31 feet at ordinary high water; and
3. A channel dredged through the "Spit," opposite the Grand Trunk wharves.

During the fiscal year ending June 30, 1874, the following additional work has been done under the several contracts previously made therefor, viz: The breakwater-extension, completed in October, 1873, for a length of 217 feet, and the old portion of the breakwater repaired throughout the granite pier at the outer end of the breakwater, also completed in October, 1873; 24,938 cubic yards of dredging done in Black Bay, by which a channel has been opened up to the "Stone-shed wharves" to a width of 100 feet and a depth of 8 feet at mean low water; the sunken wreck lying in the main ship-channel off Fort Scammel broken up and scattered into deep water; and 49,609 cubic yards of dredging done below Central wharf, in the inner harbor, in front of the harbor commissioners' line. All the work projected for the improvement of this harbor has therefore been completed, with the exception of about 200,000 cubic yards of dredging in front of the harbor commissioners' line in the inner harbor. The contract of May 10, 1873, provides for about 100,000 cubic yards of this, of which about 80,000 cubic yards are above Central wharf. But, for reasons stated by the officer in charge, it has not been deemed advisable to continue this work *above* that wharf until several projecting wharves above shall have been shortened, steps for doing which, it is understood, are now being taken by the municipal authorities. As soon as this matter is accomplished, dredging operations will be continued above Central wharf under the existing contract, and a contract will be made for additional dredging under the appropriation of June 23, 1874.

Balance in Treasury of United States July 1, 1873	\$80,000 00
Amount in hands of officer and subject to his check, (including \$727.07 percentage due on contracts not yet completed)	9,439 19

Amount appropriated by act approved June 23, 1874.....	\$20,000 00
Amount expended during the fiscal year ending June 30, 1874.....	41,113 20
Amount available July 1, 1874.....	64,816 37
Amount required for the fiscal year ending June 30, 1876.....	30,000 00

(See Appendix Y 8.)

9. *Richmond's Island, Maine.*—The improvement projected for this place consists in making a harbor of refuge by means of a rubblestone breakwater, to connect the island with the mainland. The length of the proposed breakwater is about 2,000 feet, with an average thickness of 30 feet, and a height of 13 feet above mean low water. Under the three contracts for furnishing the stone for this breakwater, 33,330 tons of stone were delivered during the fiscal year ending June 30, 1874, making a total delivered to that date of 43,189 tons, in completion of two of the contracts, and leaving about 4,000 tons to be furnished under the other contract. This contract has, since that date, been reported completed, and the appropriation for the work is exhausted. About 13,000 tons of additional stone will be required for completing this work, the estimated cost of which is \$25,000.00.

Balance in Treasury of United States July 1, 1873	\$65,000 00
Amount in hands of officer and subject to his check, (including \$2,561.55 percentage due on contracts not yet completed).....	4,972 36
Amount expended during the fiscal year ending June 30, 1874.....	60,708 49
Amount available July 1, 1874.....	8,568 53
Amount required for the fiscal year ending June 30, 1876	25,000 00

(See Appendix Y 9.)

10. *Saco River, Maine.*—The stone breakwater at the mouth of this river has been completed to the extent at present contemplated, and all the piers in the river have been rebuilt or repaired, where necessary. The channel has also been improved by the removal of several sunken rocks near Little Islands, and some dredging has been done in the harbor of Saco and Biddeford. These are all the improvements that have hitherto been projected for this river.

Balance in Treasury of United States July 1, 1873.....	\$5,000 00
Amount in hands of officer and subject to his check.....	896 20
Amount expended during the fiscal year ending June 30, 1874.....	5,896 20

(See Appendix Y 10.)

11. *Wells Harbor, Maine.*—The improvement projected for this harbor consisted in the repairs of an old Government pier at the mouth of Webhannet River. This pier was built from thirty to forty years ago for the purpose of straightening and deepening the channel over the bar at the entrance to this harbor. It was made of crib-work, ballasted with stone, and was about 250 yards in length. By act of June 10, 1872, the sum of \$5,000.00 was appropriated for this work. The projected repairs were commenced with hired labor in the latter part of September, 1872, and were completed on the 30th of June, 1873, and in September, 1873, they were entirely finished.

Amount in hands of officer and subject to his check.....	\$324 93
Amount expended during the fiscal year ending June 30, 1874.....	324 93

(See Appendix Y 11.)

12. *Cocheco River, New Hampshire.*—This river has a good navigable channel, with 6 feet of water at mean low-water (or 13½ feet at high-water) in its lowest summer stages, from the harbor of Portsmouth up to the lower narrows, distant one and a half miles below the bridge at the head of navigation in Dover. Previous to 1871 its navigation at and above the lower narrows was much obstructed by ledges, bowlders, and shoals,

having but 6 inches to 2 feet of water over them at mean low-water, so that freight destined for Dover by water had to be transhipped at Portsmouth and forwarded in scows to Dover. The average rise and fall of the tide at the lower narrows is 6.8 feet. The improvement projected for this river consisted in widening and deepening the channel through the several ledges and shoals, so as to have, in the lowest summer-stage, a depth of 4 feet at low water (or 10½ feet at high-water) for a width of not less than 40 feet, as far up as the landing, and thence up to the bridge a depth of 2 feet at low water for a width of not less than 30 feet.

The progress made in this work up to the 1st of July, 1873, consisted in opening a channel through the ledge at the lower narrows to a width of 75 feet and a depth of 4 feet at mean low-water, and in the removal of all sunken rocks from the channel between the lower and upper narrows. Since the 1st of July, 1873, a channel has been opened for a length of about 300 feet through the ledge at the upper narrows to a depth of 4 feet and a width of 40 feet at mean low-water, leaving about 130 lineal feet more to be done for its completion. Under the appropriation of June 23, 1874, a contract has been made for this work, by which it will be nearly if not quite completed before the close of the present season.

To complete all the other improvements projected for this river, the estimates for which are given in the last annual report, will require the additional sum of \$65,000.

Balance in Treasury of United States July 1, 1873.....	\$17,000 00
Amount in hands of officer and subject to his check.....	3,563 82
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	20,563 82
Amount available July 1, 1874.....	10,000 00
Amount required for the fiscal year ending June 30, 1876.....	65,000 00

(See Appendix Y 12.)

13. *Merrimac River and Newburyport Harbor, Massachusetts.*—All the work projected for the improvement of this river and harbor (including that already done) consists of the following, viz:

1. The removal of North and South Gangeway Rocks in Newburyport Harbor.

2. The removal of the rocks known as The Boilers, near the custom-house wharf, in Newburyport Harbor.

3. The removal of the wreck of the schooner *Globe*, a coal-vessel, sunk near Newburyport light-house.

4. Work for improving the navigation of the river between Newburyport and Haverhill.

5. Excavating and removing obstructions at Hazeltine Rapids and at the Upper and Lower Falls, above Haverhill, Mass., so as to have a channel 60 feet wide and 4 feet deep in the lowest stages of the river.

Up to the 1st of July, 1873, the work done under the appropriations of 1870, 1871, 1872, and 1873 was as follows, viz:

1. The main (south) Gangeway Rock, in Newburyport Harbor, was broken up and removed in 1870 to a depth of 9½ feet at mean low-water, and a commencement was made upon North Gangeway Rock.

2. The wreck of the schooner *Globe* removed in 1870.

3. Four hundred and seventy-five cubic yards of clay, bowlders, &c., excavated and removed in 1870 from the channel of the Lower Falls, above Haverhill, Mass.; 2,100 cubic yards in 1871, and 156 cubic yards in June, 1873, making a total of 2,731 cubic yards, by which the work done in these falls had been about half completed.

4. The following contracts had also been made under the appropriations of June 10, 1872, and March 3, 1873, viz: September 9, 1872, for 4,400 cubic yards of excavation in the Lower Falls and Hazeltine Rapids, and May 30, 1873, for 5,000 cubic yards of excavation in the Upper Falls. In June, 1873, 156 cubic yards were excavated in the Lower Falls, as stated above, under the contract of September 9, 1872; after which work was commenced (July 4) at the Upper Falls, under the contract of May 30, 1873. This work was continued at the Upper Falls until the 21st of October, when, owing to the high stage of the river, it was suspended until the 25th of July, 1874. The dredging up to the 21st of October, 1873, done at the Upper Falls amounted to 3,755 cubic yards, leaving about 2,800 cubic yards yet to be done for its completion.

Additional amount required for completing the work projected for the improvement of this river, \$41,000.

Balance in Treasury of United States July 1, 1873	\$45,000 00
Amount in hands of officer and subject to his check, (including \$154.62 percentage due on contracts not yet completed)	3,694 47
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874	15,665 50
Amount available July 1, 1874	39,471 09
Amount required for the fiscal year ending June 30, 1876	41,000 00

(See Appendix Y 13.)

14. *Gloucester Harbor, Massachusetts.*—Under the appropriation of June 10, 1872, the removal of the following sunken rocks has been completed, viz: Clam Rock, Pinnacle Rocks, rocks off J. Friend's wharf, rock off Pew's wharf, and Babson's ledge, to the extent projected.

Amount in hands of officer and subject to his check	\$9,470 64
Amount expended during the fiscal year ending June 30, 1874	8,783 80
Amount available July 1, 1874	686 84

(See Appendix Y 14.)

15. *Salem Harbor, Massachusetts.*—The work projected for the improvement of this harbor consists of the excavation of a channel 1,730 feet long and 300 feet wide, to a depth of 8 feet at mean low-water or 173 feet at mean high-water, from deep water to the entrance of South River, and for the construction of a sea-wall and breakwater for the protection and preservation of Long Point, at an estimated cost of \$48,000.

Under the appropriation of March 3, 1873, 31,496 cubic yards of dredging was done by contract, whereby the channel was opened to the required depth of 8 feet at mean low-water, from deep water to the entrance of South River, for an average width of 160 feet.

The appropriation of June 23, 1874, will be applied to the completion of this channel.

The additional amount required for the completion of the projected improvements, as estimated by Lieutenant-Colonel Thom since the transmission of the estimates from this office, in August last, is \$23,000.

Balance in Treasury of United States July 1, 1873	\$8,000 00
Amount in hands of officer and subject to his check, (including \$815.54 percentage due on contracts not yet completed)	3,455 51
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874	11,455 51
Amount available July 1, 1874	10,000 00
Amount required for the fiscal year ending June 30, 1876	23,000 00

(See Appendix Y 15.)

16. *Boston Harbor, Massachusetts.*—The several works projected and in progress for the preservation and improvement of this harbor are as follows, viz:

1. The sea-wall for the protection and preservation of Point Allerton.
2. The sea-wall for the protection and preservation of Great Brewster's Island.
3. The sea-walls for the protection and preservation of Lovell's Island.
4. The sea-wall for the protection and preservation of Gallop's Island.
5. The sea-wall for the protection and preservation of the north head of Long Island.
6. The sea-walls for the protection and preservation of Deer Island.
7. Straightening, widening, and deepening the main ship-channel in the Narrows.
 - (a.) At the west end of Great Brewster Bar;
 - (b.) At the southeast point of Lovell's Island; and
 - (c.) At the southwest point of Lovell's Island.
8. Widening and deepening the channel through the Upper Middle Bar.
9. Removal of Nash's Rock.
10. Completing the removal of Kelly's Rock.
11. Removal of a sunken ledge situated in the Narrows, between George's Island and Great Brewster Spit.
12. Removal of State and Palmyra Rocks on the southern spurs of the Lower Middle.
13. Surveys of sunken rocks.

The following is a statement of the progress made upon these several works, and their condition, during the fiscal year ending June 30, 1874, viz :

1. *Sea-wall on Point Allerton.*—This wall was completed by contract, in May, 1874, the work done since July 1, 1873, being as follows, viz: 132 linear feet of granite wall built, (including facing, concrete foundation, backing, and coping;) 595 cubic yards excavation for the foundation; 3,351 cubic yards of earth back-filling; 1,905 superficial yards of granite paving; whereby the sea-wall was entirely completed to its projected length of 1,202 feet. For the protection of the concrete foundation of this sea-wall from injury by the storms and currents to which it is exposed, 1,005 linear feet of stone apron was laid in front of its faces, and eight stone jetties built at the angles and elsewhere, where most necessary.

2. *Sea-wall on Great Brewster's Island.*—This work was completed in 1870. It is in good condition, and does not require repairs.

3. *Sea-walls on Lovell's Island.*—There are two sea-walls on this island, one of which was built thirty years ago, for the protection of the north head, and the other in 1867-'68, for the protection of the southeast bluff, for a length of about 800 feet. During the past year all the projected apron-work has been built, and all the necessary repairs made on these walls, (they were completed in August, 1873,) as follows: The stone jetty at the southern end of the north head, taken down and relaid in concrete, and a stone apron built for the protection of the shore south of it, for a length of 620 feet; also a stone apron, 110 feet in length, built for protecting the shore south of the wall, at the southeast bluff.

4. *Sea-wall on Gallop's Island.*—This wall was completed in September, 1871. The violent storms and currents to which it is exposed, having laid bare its concrete foundation in places, with a probability of still greater injury occurring, it was decided to build for its protection and preservation a rubble-stone apron, with jetties, where necessary. This work was commenced in August, 1873, and completed in April, 1874. The apron extends along the faces of this wall for a length of 1,655 feet,

and the jetties, eight in number, are built perpendicularly thereto, at and near the most exposed angles.

5. *Sea-wall on north head of Long Island.*—Work upon this wall has been continued during the past year under a contract made May 8, 1873, for its completion. Since the 1st of July, 1873, 380 linear feet of granite wall (including facing, coping, concrete foundation, and backing) have been built, and 776 cubic yards of excavation for the foundation have been done, whereby the granite wall proper was completed in September, 1873, to its projected length of 2,080 feet; and up to the close of the fiscal year ending June 30, 1874, 3,770½ cubic yards of earth back-filling were placed behind this sea-wall, and 3,038 superficial yards of granite paving laid upon the back-filling, leaving to be done for the entire completion of the sea-wall 550 cubic yards of back-filling and 353 superficial yards of granite paving, which were completed in July, 1874. For the protection of the concrete foundation of this sea-wall from injury by the storms and currents to which it is exposed, 975 linear feet of stone apron-work and 10 stone jetties have been built on its most exposed faces and angles. This apron-work was commenced in April and completed about the 1st of August, 1874.

8. *Sea-walls on Deer Island.*—The three sea-walls on this island were built about thirty-five years ago, for the protection and preservation of the north, middle, and south heads. These walls have from time to time been repaired and in part built. During the autumn of 1873 the lower courses of the north-head wall were repaired in numerous places, and the granite paving in rear of the wall laid and repaired where necessary.

7. *Straightening, widening, and deepening the main ship-channel in the Narrows.*—This improvement consists in the removal of portions of Brewster's Spit and Lovell's Island, so as to obtain a depth of 23 feet at mean low water for a width of 600 feet. Work was commenced in 1867 on the southwest point of Lovell's island, but for want of funds was suspended in 1869. A re-survey of this locality, made in 1872 under the direction of the engineer-officer in charge, showed that the channel at the southwest point of Lovell's Island has not changed to any considerable extent since the dredging operations were suspended in 1869; that the flats off the southeast point of Lovell's Island have advanced so much toward the main channel as to materially impede and endanger navigation; also that the extreme westerly end of Brewster's Spit has continued to extend in a westerly and southwesterly direction, so that the present 18-foot curve is 168 feet from that of 1860. This channel will be improved, as projected, at the western extremity of Brewster's Spit and at the southeast point of Lovell's Island, with the appropriation of June 23, 1874.

8. *Widening and deepening the channel at the Upper Middle Bar.*—This work consists in the excavation of a channel 600 feet wide, for a depth of 23 feet below the plane of mean low-water and for an average length of 2,200 feet. On the 1st of July, 1873, the work then done amounted to the excavation of 46,425 cubic yards, by which one entire "cut" and half of a second "cut" were completed, each for a width of 40 feet, and to the required depth. Under a contract made March 5, 1874, for 75,000 cubic yards of dredging, in continuation of this work, 8,476 cubic yards of dredging was done up to the 30th June, 1874, whereby the channel was enlarged to an average width of about 80 feet. On the 1st of September, 1874, still another contract was made for about 50,000 cubic yards of dredging, in continuation of this work, under the appropriation of June 23, 1874, to be completed in August, 1875. On the completion of these contracts about 110,000 cubic yards of additional dredging will be re-

quired for completing this work, the estimated cost of which, including contingencies, is \$100,000. The great importance of this work makes it desirable to have it completed at as early a day as practicable.

9. *Removal of Nash's Rock.*—This is a shoal lying in the entrance to Boston Harbor, about one-third of the way over from Brewster's Spit to Point Allerton. A survey made in the autumn of 1873, under the direction of the engineer-officer in charge, shows that this shoal has an area of about 9 acres, over which there is less than 23 feet of water at mean low-water, of which only about 640 superficial yards have a depth of less than 21 feet at mean low-water. As the cost of increasing the depth over this shoal to a depth of 23 feet at mean low-water would be greatly disproportionate to the benefit that would arise therefrom, an estimate is submitted for a depth of 21 feet, at \$5,000.

10. *Completing the removal of Kelley's Rock.*—This rock lies in the main ship-channel, distant about 700 yards in a direction southeast by south from Bug Light (at the Narrows) and in the line of Entrance-buoy No. 1 and Bug Light, and is a very dangerous obstruction to navigation. Its removal to a depth of 23 feet at mean low-water was commenced in 1869, and continued with intervals up to the close of the year 1870, but not completed. About 118 tons of stone were also removed from it in June and July, 1873, leaving about 80 cubic yards more to be removed in order to obtain the projected depth of 23 feet over it. This work will be undertaken at once, with a view to its completion at an early day, with the appropriation of June 23, 1874.

11. *Removal of sunken ledge in the Narrows, between George's Island and Great Brewster's Spit.*—This ledge was discovered in September, 1872, in a re-survey of the Narrows, made under the direction of the engineer-officer in charge. It lies in the main ship-channel, distant 317 yards in a direction west by south from Bug Light, and has but 19 feet of water over it at mean low-water. To obtain a depth of 23 feet at mean low-water requires the removal of about 16 cubic yards of ledge, for which a contract has been made.

12. *Removal of State and Palmyra Rocks.*—An accurate survey was made of these rocks in August, September, and October, 1873, in order to ascertain their extent and location, and with a view to the removal of such as might be deemed necessary. By this survey several sunken ledges and bowlders were discovered on southern spurs of the Lower Middle, of the position and character of which but little had previously been known, except that ocean-steamers and other vessels had occasionally struck upon them. The removal of these rocks to the extent recommended by the engineer-officer in charge, it is estimated, will cost about \$1,500, for which a contract has been made. He also states that the suitable placing of buoys Nos. 8 and 9 would greatly improve the navigation of this part of the harbor.

13. *Surveys of sunken rocks.*—During the past year examinations have been made of the shoals east of Great and Little Faun, in Broad Sound, in order to ascertain the locality of certain dangerous rocks, the existence of which had been reported, and surveys have been made in the narrows for a similar purpose; but no rocks have been discovered which require further attention.

Balance in Treasury of United States July 1, 1873	\$151,442 15
Amount in hands of officer and subject to his check	4,321 90
Amount appropriated by act approved June 23, 1874	100,000 00
Amount expended during the fiscal year ending June 30, 1874	93,041 46
Amount available July 1, 1874	151,710 70
Amount required for the fiscal year ending June 30, 1876	120,000 00

(See Appendix Y 16.)

17. *Duxbury Harbor, Massachusetts.*—The work projected for the improvement of this harbor consisted in straightening and widening south channel at Splitting-Knife Bar, and the spit next below, so as to obtain a width of 200 feet for a depth of 8 feet at mean low-water. Under the appropriations of June 10, 1872, and March 3, 1873, contracts were made for the required dredging, which was commenced in June, 1873, and completed in May, 1874, so that no further appropriation is required for this work.

Balance in Treasury of United States July 1, 1873	\$11,976 00
Amount in hands of officer and subject to his check, (including \$258.52 percentage due on contracts not yet completed)	6,663 54
Amount expended during the fiscal year ending June 30, 1874	18,639 54

(See Appendix Y 17.)

18. *Plymouth Harbor, Massachusetts.*—The work projected for the improvement of this harbor consists in the construction and repair of bulkheads, jetties, and groins built for the protection and preservation of Long Beach, which serves as a breakwater, and affords to the harbor inside the only shelter it has from easterly storms. These bulkheads and jetties are built either of stone or else of crib-work and brush ballasted with stone, and the groins of stone and of brush, and sometimes of the two combined.

This work has been carried on at intervals during the past year with results as follows, viz: Built twenty-three groins of brush and stone, having an aggregate length of 3,000 feet, ten groins of brush alone, having an aggregate length of 534 feet; over 10,000 hills of beach-grass planted, and repairs made where necessary upon the bulkheads and jetties. This work will be continued with the appropriation of June 23, 1874

Balance in Treasury of United States July 1, 1873	\$3,000 00
Amount in hands of officer and subject to his check	1,288 85
Amount appropriated by act approved June 23, 1874	5,000 00
Amount expended during the fiscal year ending June 30, 1874	3,860 90
Amount available July 1, 1874	5,427 92
Amount required for the fiscal year ending June 30, 1876, (as revised in this Office)	28,000 00

(See Appendix Y 18.)

19. *Wellfleet Harbor, Massachusetts.*—By act of June 10, 1873, the sum of \$5,000 was appropriated for removing the *sunken rocks* at the entrance of this harbor. All the most dangerous rocks have been removed, including Channel Rock, Mayo's Rock, Bay Rock, Lobster Rock, and Lumpfish Rock, the removal of the last three having been completed in July, 1873; in addition to which other sunken rocks, not provided for by contract, have been removed by hired labor, one lying about 70 feet from Channel Rock and nearer the mid-channel, and others near Bay Rock, altogether containing about 50 cubic yards.

Amount in hands of officer and subject to his check	\$4,179 69
Amount expended during the fiscal year ending June 30, 1874	4,179 69

(See Appendix Y 19.)

20. *Provincetown Harbor, Massachusetts.*—Under the several appropriations heretofore made for the preservation and improvement of this harbor the following work had been done on the 1st of July, 1873, viz:

1. Bulkheads and jetties of various descriptions built, from time to time, along Beach Point, for its preservation and protection, both by the United States and by the local authorities.

2. A dike built in 1868 and 1869, by the State of Massachusetts, across the outlet of East Harbor Creek.

3. A dike built in 1868 and 1869, by the United States, across East

Harbor Creek, at the Wading Place, near High Head, about two miles above the outlet of the creek.

4. Wooden bulkheads and jetties, built at different times, for the protection and preservation of the beach on Long Point.

5. A stone bulkhead commenced for the protection and preservation of the outer end of Long Point, opposite the light-house and 3-gun battery.

6. A substantial dike, (272 feet in length,) built in 1871-'72, across the head of Lancey's Harbor, near Abel Hill.

7. Beach-grass planted on Beach Point, Long Point, Abel Hill, Cove Section, and Oblique Section, and at the last two places brush had also been laid for their further protection.

8. The projected extension of the several jetties on Beach Point and State Dike nearly completed; and,

9. Accurate re-surveys made (in 1871, 1872, and 1873) of Cove Section, Oblique Section, Beach Point, and Long Point, together with elaborate soundings and current observations in the inner harbor.

Of the several appropriations made for the improvement of this harbor there was, on the 1st of July, 1873, an unexpended balance of \$2,368.82, which has been applied as follows, viz:

1. To the completion of all the jetties on Beach Point and State Dike to the extent projected, and of brush and stone groins connecting the outer ends of the jetties.

2. To the repairs of the bulkhead and jetties on Beach Point and State Dike, and beach-grass planted where most necessary.

3. To rebuilding and strengthening the outer end of the stone bulkhead on Long Point; and,

4. To building at Cove Section a bulkhead of timber and brush, ballasted with stone, 190 feet long, rendered necessary for the protection and preservation of the beach at that place, from the fact that by the extraordinary gale of November 16, 1873, the crest line of the shore, for an extent of about 200 feet, had been carried 30 feet inward and lowered about 3 feet, so as to have a height of only about 10 feet above the plane of ordinary high-water. This bulkhead was completed about the middle of January, 1874.

Balance in Treasury of United States July 1, 1873.....	\$3,000 00
Amount appropriated by act approved June 23, 1874.....	6,000 00
Amount expended during the fiscal year ending June 30, 1874.....	2,233 14
Amount available July 1, 1874.....	6,103 48
Amount required for the fiscal year ending June 30, 1876.....	5,000 00

(See Appendix Y 20.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENTS.

Lieutenant-Colonel Thom was charged with, and has completed during the past fiscal year, the following examinations and surveys provided for by act of March 3, 1873:

1. *Aroostook River, Maine, for improvement of the channel.*
2. *Penobscot River, from Oldtown to Medway and vicinity, Maine.*
3. *Portsmouth Harbor, New Hampshire, for a breakwater between Gerish's Island and Wood Island.*

4. *Ipswich Bay, Massachusetts, at Hodgkin's Cove, to ascertain the practicability of a harbor of refuge by building a breakwater there.*

The several reports upon these surveys were transmitted to Congress at its last session, and printed in Ex. Doc. H. R., No. 84.

(See Appendixes, Y 21, Y 22, Y 23, and Y 24.)

To comply with a resolution of the House of Representatives of December 10, 1873, Lieutenant-Colonel Thom was directed to make an examination of Plymouth Harbor, Massachusetts, with a view to its improvement. His report thereon was also transmitted to Congress, and was printed in Ex. Doc. H. R., No. 161.

(See Appendix Y 25.)

PACIFIC COAST

IMPROVEMENT OF RIVERS IN OREGON.

Officer in charge Maj. N. Michler, Corps of Engineers, since October 22, 1873, previous to which time these improvements were in charge of Maj. H. M. Robert, Corps of Engineers.

1. *Improvement of Lower Willamette River, Oregon.*—A new dredge was completed shortly after the commencement of the fiscal year, and was subsequently employed upon the bar at the mouth of the river, and at Post-Office Bar. At the mouth a channel-way was reopened for a length 1,800 feet and width 120 feet. At Post-Office Bar a cut was made of 1,552 feet in length, with a width of 30 feet and depth 17 feet. At Percy's Slough, near the mouth, a dam is being built. The appropriation for the present fiscal year will be applied to keeping the channel of the Willamette open. A survey of Willamette Slough will be made.

2. *St. Helen's Bar, Columbia River, Oregon.*—Surveys of the bar will be continued, and the channel kept open by dredging.

3. *Mouth of the Columbia River, Oregon.*—The survey and soundings at the "Hog-back," between Tongue Point and Woody Island, were completed by the close of the fiscal year. A new channel was dredged or scraped out, marked by an iron beacon and black and white buoys. It is proposed during the present fiscal year to continue similar operations at this locality.

Balance in Treasury of United States July 1, 1873:

Lower Willamette	\$10,793 36	
Obstructions	9,206 64	
		20,000 00
Amount appropriated by act approved June 23, 1874.		20,000 00
Amount expended during the fiscal year ending June 30, 1874		14,678 15
Amount available July 1, 1874*		5,321 85
Amount required for the fiscal year ending June 30, 1876.		20,000 00

(See Appendixes Z 1 and Z 4.)

4. *Improvement of the Willamette River above Oregon City, Oregon.*—The operations consisted in the removal of dangerous snags and other serious obstructions. Two hundred and eighty snags were removed during the season, among them at Luckamutte, the "Big Pine," with those adjacent. In addition to the continuation of the work of removal of snags during the present fiscal year, the construction of wing-dams will be undertaken at certain points.

Balance in Treasury of United States July 1, 1873	\$1,500 00
Amount appropriated by act approved June 23, 1874	7,500 00
Amount expended during the fiscal year ending June 30, 1874	1,500 09
Amount required for the fiscal year ending June 30, 1876	25,000 00

(See Appendixes Z 2 and Z 4.)

5. *Improvement of the Upper Columbia River, Oregon.*—The removal of rock in John Day, Devil's Bend, and Umatilla rapids of this river

*Of the amount available July 1, 1874, must be deducted \$4,800 for building dam across Percy's Slough, which is not yet completed.

has been continued. Rocks were removed from Devil's Bend and Umatilla rapids during the working season to the amount of 465 cubic yards. The total quantity of rock removed by contract is 1,425 cubic yards.

The work proposed for the present fiscal year is the widening of the channel of the Upper Umatilla Rapids, and the removal of rock from Homly Rapid, Squally Hook Rapid, Owyhee Rapid, and Rock Creek Rapid, so as to give the same depth of water as that already obtained on the above-named points.

Balance in Treasury of United States July 1, 1873.....	\$9,000 00
Amount in hands of officer and subject to his check	19,183 76
Amount appropriated by act approved June 23, 1874.....	20,000 00
Amount expended during the fiscal year ending June 30, 1874	28,085 11
Amount available July 1, 1874	98 65
Amount required for the fiscal year ending June 30, 1876.....	40,000 00

(See Appendixes Z 3 and Z 4.)

6. *Umpqua River, Oregon.*—No additional work was done toward the improvement of the navigation of this river during the fiscal year.

There is a balance remaining of the appropriation of March 3, 1871, \$4,685.89.

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Provision was made in the act of March 3, 1873, for a "*Survey or examination of the mouth of Coquille River, Oregon,*" and upon investigation of its object, instructions were given to Major Michler to extend the examination so as to embrace the general question of a navigable outlet to Coquille River. His report thereon was transmitted to Congress at its last session, and printed in Ex. Doc. H. R., No. 216.

(See Appendix Z 5.)

BREAKWATER AT WILMINGTON, CALIFORNIA—REMOVAL OF RINCON ROCK IN THE HARBOR OF SAN FRANCISCO.

Officer in charge, Maj. G. H. Mendell, Corps of Engineers, with Lieut. O. B. Sears, Corps of Engineers, under his immediate orders.

1. *Breakwater at Wilmington, California.*—At the date of the last annual report the timber construction was completed and about two-thirds of the stone line was finished. The stone line is 2,000 feet long. It was completed in the past year.

The double-piled work, which is 1,000 feet in length, and which stood in 5 feet of water, was filled with stone to the height of 3 feet above mean low-water, and ballasted on both sides with gravel and stone to half tide. The single line of piled work was ballasted to the same height for a distance of 2,200 feet.

Two stone jetties, aggregating 980 feet in length and rising from 2 to 4 feet above the lowest stage of the tide, were built, with the object of directing and controlling the action of the current. They had the effect to increase the depth of water on the bar.

A number of short jetties, aggregating 700 feet in length, were built along the main line, for the double purpose of preventing the work from undermining and to favor the accumulation of sand along the line. These works, as mentioned, consumed 25,778 tons of stone and gravel.

A careful hydrographic survey of the lower part of the estuary was made and proposals issued for excavating a channel. No bids being

offered, new proposals, to dredge by the cubic yard, were issued. A favorable bid has been accepted since the close of the fiscal year.

It is now expected that the funds on hand will be sufficient to provide a channel 200 feet wide and 10 feet deep at mean low-water, and, in addition, to build some training-walls for the better security of the channel when excavated. These results will probably be attained in the next fiscal year.

The amount asked for the next year is intended for the protection of the timber-work.

Balance in Treasury of United States July 1, 1873.....	\$145,647 07
Amount expended during the fiscal year ending June 30, 1874.....	71,025 08
Amount available July 1, 1874.....	74,621 99
Amount required for the fiscal year ending June 30, 1876.....	30,000 00

(See Appendix A A 1.)

2. *Removal of Rincon Rock, harbor of San Francisco, California.*—A contract was made in September, 1873, for the removal of this rock to the depth of twenty-four feet at mean low-water, before June 1, 1874, for \$43,000, but an extension of time to October 1, 1874, has been granted.

The work was begun in October, and to the 30th June, 1,650 cubic yards of rock were removed, leaving 3,150 cubic yards yet to be removed.

No appropriation is asked for the coming year.

Balance in Treasury of United States July 1, 1873.....	\$48,500 00
Amount in hands of officer and subject to his check, July 1, 1873.....	221 71
Amount expended during the fiscal year ending June 30, 1874.....	8,147 44
Amount available July 1, 1874.....	33,632 65

(See Appendix AA 2.)

HARBOR OF SAN DIEGO, CALIFORNIA.

In my annual report of October 19, 1872, it was stated that Lieut. Col. B. S. Alexander, Corps of Engineers, had called the attention of this office to the probable filling up of the upper portions of this harbor, and that he had accordingly been directed to determine, if possible, the cause and extent of this filling. In addition to facts previously presented he reports the effects of the flood in San Diego River during the past winter, with suggestions as to the proper means to be applied to prevent the threatened injury, and recommends an appropriation of \$80,000 for the purpose of turning the course of the river into False Bay.

(See Appendix A A 3.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

The examination at *Santa Cruz, California*, required by the act of March 3, 1873, was assigned to Lieut. Col. C. S. Stewart, Corps of Engineers, whose report thereon was transmitted to Congress at its last session, and printed in H. R. Ex. Doc. No. 84.

(See Appendix A A 4.)

A board of engineer-officers was constituted in March, 1873, for the purpose of making an examination and survey and the plan for a harbor at *San Antonio Creek, San Francisco Bay*, as directed by the act of March 3, 1873. Its report thereon was transmitted to Congress at its last session, and printed in H. R. Ex. Doc. No. 174.

(See Appendix AA 5.)

IMPROVEMENT AND CARE OF THE PUBLIC BUILDINGS AND GROUNDS IN
THE DISTRICT OF COLUMBIA.

Officer in charge, Col. O. E. Babcock, Corps of Engineers.

The condition of the public reservations in the city of Washington, and the character of the improvements made on them during the fiscal year closed, will be found in the detailed report of the officer in charge.

The estimates for the fiscal year ending June 30, 1876, are as follows:

For improvement and care of the public buildings and grounds.....	\$344,816 50
For compensation to persons employed on and around public buildings and grounds.....	53,016 00
	\$397,832 50

(See Appendix B B.)

SURVEYS AND EXAMINATIONS WITH A VIEW TO THE IMPROVEMENT
OF RIVERS AND HARBORS.

For examinations and surveys of rivers and harbors, and for incidental repairs at harbors for which there is no special appropriation, an appropriation of \$150,000 should be made.

SURVEY OF NORTHERN AND NORTHWESTERN LAKES.

Officer in charge, Maj. C. B. Comstock, Corps of Engineers, who has under his immediate orders the following officers of the Corps of Engineers: First Lieuts. H. M. Adams, D. W. Lockwood, E. Maguire, C. F. Powell, and Second Lieut. T. N. Bailey; and the following assistant engineers: J. B. Mayer, O. B. Wheeler, A. C. Lamson, E. S. Wheeler, G. Y. Wisner, A. R. Flint, G. A. Marr, H. Custer, and F. M. Towar.

Progress of the work during the year.—The field-work of the connection of the triangulations of Lake Superior and Lake Michigan has been completed; the topography, in-shore hydrography, and off-shore hydrography of Lake Michigan have been finished.

The Wisconsin triangulation has been completed southwardly to the vicinity of Chicago. The Keweenaw base has been remeasured.

The survey of the Detroit River has been completed and a map published of its lower half.

The triangulation, topography, and hydrography of the St. Lawrence River, from the 45th parallel to Lake Ontario, have been completed.

The positions of several points in the interior of Michigan and Wisconsin have been determined in aid of State surveys.

The survey of Lake Ontario has been begun; much of the field-work has been reduced.

Charts No. 1, of the St. Lawrence, of Sandusky Harbor, of Chicago, and of mouth of Detroit River, have been completed.

It is proposed during the present fiscal year to complete the triangulation at south end of Lake Michigan, to continue the determination of points in the interior of Michigan, to continue the survey of Lake Ontario, and to commence the triangulation connecting Lake Michigan and Lake Erie.

The need that the survey of the Lakes should be vigorously prosecuted is best shown by the number of charts required by the commerce of the lakes, now five or six thousand a year, and by the constant inquiry and pressure for charts not yet completed, or for which not even the surveys have, as yet, been made.

It is judged that the single survey made last year of the mouth of De-

troit River and of a part of Lake Erie will save from \$50,000 to \$100,000 to commerce this year.

Amount expended during fiscal year 1873-4	\$175,000
Amount available for fiscal year 1874-5	175,000
Amount required for survey of northern and northwestern lakes for fiscal year ending June 30, 1876:	
For continuation of surveys of Lakes Ontario and Erie, determination of points in Michigan in aid of State survey, extension of triangulation south from Chicago, and miscellaneous	219,000

Estimate of funds for continuance of the survey of the northern and northwestern lakes for the fiscal year ending June 30, 1876.

Continuance of survey of Lake Ontario and reduction of the work.

Triangulation, six parties	\$30,000
Topography, four parties	52,000
Hydrography, two steamer parties	30,000

Survey of Lake Erie, and reduction of the work.

Triangulation, four parties	\$20,000
Topography, two parties	26,000
Hydrography, one steamer-party	15,000
<i>Survey of Lake Michigan.</i> —Reduction of previous work, determination of points in interior of Michigan in aid of State survey, and extension of triangulation south from Chicago	25,000
<i>Miscellaneous.</i> —Water-level and meteorological observations and reductions \$5,000; transportation of parties, quarters and fuel for officers \$6,000; office-rent, fuel, stationery and instruments \$5,000; completion of unfinished work \$5,000	21,000
Total	219,000

(See Appendix CC.)

MILITARY MAPS.

The survey of the battle-fields in the valley of the Shenandoah, by Maj. George L. Gillespie, acting under the orders of Lieutenant-General Sheridan, which was mentioned in my last annual report as in progress, was completed in October, 1873, and arrangements have been entered into for printing the maps. On the completion of the field-work the office of the survey was transferred from Winchester, Virginia, to the headquarters of the Lieutenant-General.

(See Appendix DD.)

The map of the battle-field of Gettysburg, in charge of Maj. G. K. Warren, has been completed in regard to the engraving of its topography, and an agreement has been entered into with Mr. J. B. Bachelder to prepare sets of three maps, each to be in three sheets, showing the positions of both armies on the mornings and evenings of July 1, 2, and 3.

In this office:

Of the Atlanta campaign maps, which are being recompiled in this office, one sheet is nearly completed, and on two sheets considerable progress has been made.

A map of the battle-field of Franklin has been published. A new addition of General Sherman's campaign has been printed and will form one of a series of campaign maps similar to those of the operations of the armies of the Potomac and James. A map of the battle-field of Chickamauga (in two sheets) is in preparation for publication. The railroads shown on the map of the Territories of the United States west

of the Mississippi River were corrected to June, 1873, and an edition has since been published. The military map of the United States has been revised and a new edition has been printed. This map shows the boundaries of the military departments and all of the military posts in the United States.

The final chart No. 3, of Lake Superior, and a chart of the harbor of Sandusky, are now being engraved.

A chart of the river St. Lawrence from Strawberry Island to St. Regis, a chart of Lake St. Clair, and a lake-survey map of the city of Chicago will be engraved as soon as a preliminary edition has been photo-lithographed. Sheet No. 2 of Nebraska, in the Military Department of the Platte, and a campaign map of that department, in four sheets, embracing parts of Nebraska and Wyoming, and derived from surveys by Capt. W. A. Jones, of the Engineers, have been published.

GEOLOGICAL EXPLORATION OF THE FORTIETH PARALLEL.

Mr. Clarence King, United States civil engineer, in charge.

The only field-work undertaken during the past year was a geological reconnoissance over parts of Western Nevada and adjacent California, made especially to study certain developments of the Achæan formations and for the purpose of obtaining data bearing on the classification of mining districts. The reconnoissance was made by the geologist in charge unaccompanied, and extended from September 2, 1873, to December 13, 1873.

The party has been in office during the entire year, preparing the report and accompanying illustrations. The series of topographical maps have been completed and put in the hands of the engraver. The preliminary work for the reports, consisting of chemical, paleontological, and microscopical research, have been carried on with success.

Analyses sufficient to determine many important chemical questions have been made, referring chiefly to waters, alkaline and saline deposits, and those of ores and rocks are now progressing. Microscopical research has been and is now being pursued with the promise of systematically identifying American rocks with known European types, a labor now attempted for the first time. The paleontology, already delayed by Professor Meeks' ill health, is now nearing completion, under Hall and Whitfield, of Albany. Illustrations for the two geological volumes are progressing. It is confidently expected by the officer in charge that the labors of this exploration party will be brought to a close within a year from this time.

(See Appendix E E.)

GEOGRAPHICAL EXPLORATIONS AND SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN IN CALIFORNIA, NEVADA, UTAH, ARIZONA, COLORADO, NEW MEXICO, WYOMING, AND MONTANA.

Officer in charge, First Lieut. George M. Wheeler, Corps of Engineers, having under his orders First Lieuts. R. L. Hoxie, W. L. Marshall, S. E. Tillman, and P. M. Price, Corps of Engineers, Second Lieut. A. H. Russell, Third United States Cavalry, and, during portion of the field-season, Lieuts. H. R. Brinkerhoff and L. H. Walker, Fifteenth United States Infantry, as escort officers, Acting Assistant Surgeons J. T. Rothrock, H. C. Yarrow, and C. G. Newberry, United States Army, who, in addition to their professional duties, were engaged in botanical, ornithological, and natural-history labors.

Active field-operations were in progress at the commencement of the fiscal year, the three main divisions of the expedition having departed from their rendezvous at Salt Lake City, Utah, Denver, Colorado, and Santa Fé, New Mexico, moving south into Arizona, connecting with work of former years, covering during the season, an area of about 75,000 square miles, and disbanding at the close of the field-season in November and December.

Following the disbanding a sufficient number of the members to prepare the matured results returned to Washington, where they were engaged during the winter months, and where a small force of draughtsmen and computers are continuously engaged in elaborating the material gathered in the field.

In addition to topographical work proper the survey combines the establishment of numerous points astronomically; (an important feature in relation to many public and private interests;) observations in meteorology and hypsometry; investigations in geology, mineralogy, and natural history; and the gathering of many other facts upon subjects bearing upon the industries and resources of the regions traversed. A mass of useful information and results is thus constantly being accumulated and made available to the Government and the public.

By experience and improvements in methods and instruments, the value of the results is annually enhanced and the cost of the work amply repaid.

Final results in the astronomical and other branches of the work have appeared, and additional will be ready for the press and engravers before the close of the present year.

The expedition for the present field-season is well organized and equipped, and the officer in charge is sanguine of most satisfactory results. The field of operations lies in southern and southwestern Colorado, northern and northwestern New Mexico, and northwestern Arizona. Several primary astronomical stations will be determined in addition to astronomical observations in the field, and the astronomical observatory at Ogden, Utah, will be well advanced toward completion.

Lieutenant Wheeler submits estimates —

For continuing the exploration	\$95,000
For engraving and printing the plates and atlas-sheets accompanying the reports of the geographical explorations and surveys west of the 100th meridian.....	25,000

His annual report and estimates are appended.

(See Appendix FF 1 and FF 2.)

Lieutenant Wheeler has also submitted a report of Prof. E. D. Cope, paleontologist, from his camp, on Galinas Creek, in the Rio Grande basin, including a description of new species of vertebrate fossils, and of an extensive series of deposits of the Eocene age, indicating the existence, in earlier geological time, of an extensive lake of fresh water in that part of New Mexico.

The collections made and to be made by this special party are likely to prove of unusual interest.

(See Appendix FF 3.)

RECONNOISSANCES AND EXPLORATIONS.

Officers of the Corps of Engineers have been on duty during the last year at most of the headquarters of the military divisions and departments, where they have been charged with the preparation of detailed maps and sketches, required by the generals commanding, and with the

collection of the topographical information required in the compilation of the maps engraved and distributed by the Engineer Department.

The following officers have been thus serving : Maj. O. M. Poe, aid-de-camp with the rank of colonel, at the headquarters of the Army ; Maj. J. W. Barlow, at the headquarters of the Division of the Missouri ; Capt. G. J. Lydecker, until the 16th of March, 1874, and Lieut. J. G. D. Knight since that date at the headquarters of the Division of the Pacific ; Capt. W. A. Jones, at the headquarters Department of the Platte ; Capt. Wm. Ludlow, at headquarters Department of Dakota ; Capt. A. H. Holgate, at headquarters Department of Texas ; and Lieut. E. H. Ruffner at headquarters Department of the Missouri.

Maj. J. W. Barlow, on duty with the Lieutenant-General of the Army, commanding the Military Division of the Missouri, was employed in the compilation of the results of labors of the engineer officers on duty at the headquarters of the departments of the division.

Astronomical observations formed an important part of these surveys, and they served to correct the positions of several points. Maps of all the reservations of the division and plats of the posts, about 60 in number, have been made, of a uniform size, to accompany printed outline descriptions of these reservations and posts.

The longitude of Bismarck on the Missouri, the present terminus of the Northern Pacific Railroad, was determined by telegraph ; the latitudes of Bismarck, and Fargo, an important town in the northwest, were also determined.

(See Appendix G G.)

Capt. W. A. Jones, on duty at headquarters Department of the Platte, was, at the beginning of the last fiscal year, engaged in a reconnoissance of the country lying about the headwaters of the Yellowstone, Snake, Green, Wind, Big Horn, Gray Bull, Clark's Fork, and Stinking Water rivers, an extremely mountainous area in the northwestern part of the Territory of Wyoming, and which had previously been to a great degree unexplored.

The outlines and character of a remarkable range of mountains, the Sierra Shoshone, lying between the valleys of the Yellowstone and the Big Horn, were ascertained. This range, which was previously almost unknown, was crossed for the first time by Captain Jones, who found there were four passes through it, two of which were discovered by him. One of the most important of the results of this expedition was the discovery of a new wagon-route leading from the southeast to Yellowstone Park and Montana. Captain Jones's report was transmitted to Congress June 16, 1874, and printed in H. Ex. Doc. No. 285, 43d Cong., 1st sess.

(See Appendix H H.)

Lieut. E. H. Ruffner, on duty with the commanding general Department of the Missouri, has been engaged in the organization of the means of collecting and arranging the information derived from the various scouting parties which have been in the field during the last year. He reports that a gratifying improvement has been made in the number and character of the journals and sketches which have been received from the officers and men ; the total number of miles covered by their journals during the last year having been 22,903 against 9,085 in the year preceding. Surveys of the military and Indian reservations at Fort Tulerosa, New Mexico, have been commenced ; a survey of Pike's Peak, for the signal-service ; a resurvey of the military reservation at Fort

Leavenworth, and a survey of a direct wagon-route from Fort Garland, Colorado Territory, to Fort Wingate, New Mexico, have been made. In my last annual report I made mention of a military reconnoissance of the country about the headwaters of the Rio Grande in Southwestern Colorado, which had been commenced in May, 1873, by Lieutenant Ruffner, under the orders of the general commanding the department. The party successfully accomplished its purpose, and also examined Gunnison's or Grand River, and the Arkansas and their approaches. Azimuth and stadia lines were run over an aggregate length of about 1,500 miles, crossing five high mountain-passes, with great success.

Lieutenant Ruffner's valuable report under the title "*Reconnoissance of the Ute Country*," and the accompanying map were transmitted to Congress March 17, 1874, and printed in H. Ex. Doc. No. 193, 43d Cong., 1st sess.

A manuscript volume, exhibiting the roads and scouts in New Mexico, which were reported in 1873, and numerous other results of the industry of the officers and men of the Department of the Missouri, which have been received at this office from time to time during the last year, evince the zeal for geographical and topographical work which has been inspired in the department by its commanding general and Lieutenant Ruffner.

Lieutenant Ruffner was also placed in charge of the completion of the military road from Santa Fé to Taos, New Mexico, which was authorized and appropriated for by act of Congress approved 3d March, 1873. He was assisted in this work by Lieut. C. C. Morrison, Sixth Cavalry, and the road was fully completed during the last season, except for a short distance, for which the funds were not sufficient. The location of the road is in the cañon of the Rio Grande, between the villages of La Joya and Cienigilla, being the same as proposed by Capt. J. N. Macomb, of the Engineers, in 1859.

(See Appendix I L.)

Capt. G. J. Lydecker, to March 16, 1874, and Lieut. J. G. D. Knight, for the remainder of the fiscal year, were on duty with the general commanding the Military Division of the Pacific.

During the year the following maps were commenced and completed, viz: Military map of the Territory of Washington; outline map of the Department of California, showing lines of transportation between different points in the department; outline map of the Military Division of the Pacific; map of Idaho, and revised map of Oregon. Map of Arizona has been commenced and is well under way.

Capt. Wm. Ludlow at the headquarters Department of Dakota, was employed during the year in the examination of the reports of journeys in the department, and in plotting the trails, when any information could be obtained from the itineraries of the officers, but most of the journals proved less valuable than could have been desired.

It is proposed to provide instruments for the posts so that the geographical and topographical work can be done by intelligent enlisted men suitably instructed and especially detailed for the purpose.

In accordance with orders from the department commander, Captain Ludlow accompanied the expedition, commanded by Lieut. Col. G. A. Custer, into the Black Hills, during the last summer. His detailed report, and the reports of the scientific gentlemen who accompanied him, will be found in the appendix.

Captain Ludlow reports that this interesting and hitherto unknown region is admirably adapted for settlement, that it abounds in timber,

grass, flowing streams, and springs; that the valleys are of gentle slope, the soil is of wonderful fertility, and that the climate is entirely different from that of the plains, it being much cooler in summer and there being evidences of being more moderate in winter.

In regard to the mineral resources of the Hills, Professor Winchell's report gives full information. No coal was found, but extensive beds of iron, gypsum, and building-stone exist. Traces of plumbago were found and specimens of gold in the soil near Harvey's Peak, as well as in quartz in bed and bowlder, were visible in considerable quantities.

The timber is mainly red pine and spruce of large size, while hardwoods, oak, ash, and elm, were found on the slope of the hills. Game, including bear, elk, and deer, (the latter of two kinds,) was found, and on the prairies antelope was found in large numbers.

(See Appendix K K.)

ESTIMATES OF AMOUNTS REQUIRED FOR MILITARY AND GEOGRAPHICAL SURVEYS, EXPLORATIONS, AND RECONNOISSANCES.

For reconnoissances and surveys for sea-coast defenses and in the military divisions and departments, \$60,000 will be required; and for geographical surveys of Territories west of the one hundredth meridian, \$95,000 will be required.

For engraving and printing the plates and atlas-sheets accompanying the reports of the geographical surveys west of the one hundredth meridian, \$25,000 will be required.

COMMISSION ON THE IRRIGATION OF THE SAN JOAQUIN, TULARE, AND SACRAMENTO VALLEYS OF CALIFORNIA.

This commission, organized by virtue of an act of Congress, and composed of Lieutenant-Colonel Alexander and Major Mendell, of the Corps of Engineers, and Professor Davidson, of the Coast Survey, has completed its labors and made a report, which was transmitted to Congress and printed in H. Ex. Doc. No. 290, 43d Cong., 1st sess.

After a careful preliminary survey and a full investigation of the subject as treated in reports on the irrigating works of foreign countries, the conclusions arrived at by the commission are that there are large bodies of land in the great valleys of California, particularly in the San Joaquin and Tulare Valleys, which require irrigation; and that, while there is an abundance of water for the purpose on the east side of those valleys, there is a scarcity of it on the west side; that, while the cost of a comprehensive system of irrigating-canals would be very great, the productions and the value of the irrigable lands, which embrace vast tracts of soil composed of the most fertile elements, would be increased many times; that experience in other countries shows that the extensive works required by a general plan of irrigation must be built either by the Government or by an association of capital; that in the latter case the franchise granted by the Government should, after a term of years, lapse in favor of owners of the irrigated lands, and, in any case, the State should establish a system of inspection by which a proper construction should be assured; it should fix the water-rates, appoint or control the persons who administer the water and collect the amounts paid by consumers, and it should see that the water-rights of the miners do not conflict with the irrigation of the plains, particularly in regard to returning the water used by them above the points at which the canals are fed.

The commission suggest that extensive irrigating-works cannot probably be built at the present time without aid from the General or State Government.

Before any scheme is begun, a careful instrumental survey should be made of the country to be irrigated, which survey should embrace the sources of water-supply and the points at which the canals should be fed; the gauging of the flow of the rivers and streams, and the defining of the boundaries of the natural districts of irrigation into which the country is divided.

The relation of the General Government to such a survey depends somewhat upon the fact that it still owns many thousands of acres in the southern part of the valleys under consideration which are capable of irrigation, but which are of no value now, and upon the national benefits that would accrue from the settlement and improvement of the whole of the irrigable areas in the interior of the country.

There is so little practical knowledge in this country, either on the part of engineers or of farmers, upon the subject of irrigation, that it is very desirable to procure from foreign countries all information relating to modern systems in those countries, and to disseminate this information throughout the country.

OFFICE OF THE CHIEF OF ENGINEERS.

In the labors of the Office I was assisted on the 30th of June by the following officers in charge of the several divisions:

FIRST AND SECOND DIVISIONS.—*Fortifications, battalion, and engineer depot, lands, armaments, personnel, &c.*, Maj. T. L. Casey.

THIRD DIVISION.—*River and harbor improvements, &c.*, Maj. J. G. Parke.

FOURTH AND FIFTH DIVISIONS.—*Property accounts, estimates, funds, survey of the lakes, explorations, maps, instruments, &c.*, Lieut. Col. J. G. Foster until June 1, 1874; from and after that date, Maj. G. H. Elliot.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
*Brig. Gen., Chief of Engineers,
Commanding Corps of Engineers.*

Hon. WM. W. BELKNAP,
Secretary of War.

APPENDIXES

TO THE

REPORT OF THE CHIEF OF ENGINEERS.

9 E

APPENDIXES
TO THE
REPORT OF THE CHIEF OF ENGINEERS.

APPENDIX A.

ANNUAL REPORT OF MAJOR F. U. FARQUHAR, CORPS OF ENGINEERS,
FOR THE FISCAL YEAR ENDING JUNE 30, 1874.

UNITED STATES ENGINEER OFFICE,
Saint Paul, Minn., July 25, 1874.

GENERAL: I have the honor to transmit herewith my annual reports of operations at the several works under my charge during the year ending June 30, 1874.

Very respectfully, your obedient servant,

F. U. FARQUHAR,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

A 1.

DREDGING OUT THE BAY OF SUPERIOR FROM THE NATURAL ENTRANCE TO THE DOCKS OF SUPERIOR AND DU LUTH, AND PRESERVING BOTH ENTRANCES FROM THE LAKE THERETO.

In this bay and the entrances thereto there are two localities at which the United States have been doing work, viz:

1st. In the vicinity of Du Luth, at northwest end of bay.

2d. At the natural entry, and in the vicinity of Superior City, at southeast end of the bay.

1. For the improvements in the vicinity of Du Luth the following specific appropriations have been made:

By act approved March 3, 1871	\$60,000
By act approved June 10, 1872	50,000
	110,000

This sum of money was expended in extending for 750 feet a break-water, commenced by the railroad company to make an outer harbor, and repairing the inner 143 feet of the same after the storms of November, 1872.

Under the act approved March 3, 1873, the following work was done, viz:

The piers on each side of the canal have been rebuilt and the revetments repaired. An opening was made through the dike and cribs placed to protect the same; and some dredging was done in the inner harbor, near the head of the canal, at the following cost:

Rebuilding and repairing piers.....	\$23, 114 34
Dredging in inner harbor	3, 325 61
Opening through dike	5, 245 25
Contingencies, &c.....	364 00
	32, 049 20

In addition there will be about \$4,000 more expended from the appropriation in continuing the dredging in the inner harbor.

The condition of the harbor of Du Luth is such that it gives no anchorage for vessels, owing to its shallowness, save in the dredged channels. The dike is almost entirely gone for from 3 to 10 feet below the surface. The revetment to the canal, which was built by the city of Du Luth, will need some repairs on account of damage done by vessels.

The amount (\$10,000) appropriated by act approved June 23, 1874, for this harbor will be expended in dredging on north side of channel, from canal to Northern Pacific Railroad docks, thus allowing vessels to turn around in the harbor, and in the slight repairs to the piers. To give the proper anchorage, and to make this harbor one of refuge, considerable dredging will have to be done. The accompanying sketch shows the areas to be dredged.

That marked A will be three-fourths dredged with existing appropriation. The total amount of material to be removed is, as shown by the survey of the Bay of Superior for a space included by the dock-lines and a line parallel to and 2,000 feet from the north dock-line, 1,078,957 cubic yards, (measured in scows,) the removal of which will cost \$269,739.25. There will be dredged with funds now available 52,000 cubic yards.

I would recommend that the dredging be done gradually, and that \$100,000 be asked for that purpose, and for the maintenance of the canal for the fiscal year ending June 30, 1876.

II. For the improvement at the natural entrance to the Bay of Superior, the following specific appropriations have been made, viz:

By act approved March 2, 1867	\$63, 000 00
Allotted from act approved April 10, 1869.....	45, 000 00
By act approved July 11, 1870.....	40, 000 00
By act approved March 3, 1871.....	60, 000 00
By act approved June 10, 1872.....	50, 000 00

Total specifically appropriated.....	258, 000 00
--------------------------------------	-------------

From the act approved March 3, 1873, there has been and will be expended on the natural entry \$63,950.80, of which amount there was spent on pier-construction and dredging between the piers (all that was contemplated in the original plan) \$41,322.64, making the total amount expended at the natural entry \$299,322.64, and in dredging from the natural entry to the docks of Superior City, \$22,628.16. For the above sum (\$299,322.64) the following work has been done: The wide opening of the outlet was closed by a rock-embankment on Minnesota Point. A pier on the Minnesota side of the outlet has been finished to a length of 2,856 feet; and on the Wisconsin side 2,656 feet more than completing

the original plan of improvement, which was estimated to cost \$309,716 for building 4,300 feet of piers and doing the necessary dredging. There is now an excellent channel of 12 feet in depth across the bar and in the entry. The only work necessary in the future is the maintenance of the channel across the bar and the repairs of the piers. I would recommend that an appropriation of \$10,000 be asked for the above work. As yet there has been no deterioration of the channel-way due to the opening of the Du Luth Canal, but if an unusually dry season occurs, accompanied by any great amount of northeast winds, a bar may form, and it would be well to be prepared for such a contingency. The opening through the dike made last June has not benefited navigation from Superior City to Du Luth, as a bar has formed on the Du Luth side on which there is only a depth of about 3 feet of water, while in the opening itself there is a depth of 31 feet. At the time of making the cut through the dike there was only 10 feet, showing that a current of considerable force passes through it. Now the small steamer has to pass through the deep opening at the west end of the dike, thus lengthening the distance sailed between Du Luth and Superior City.

I am still of the opinion that the dike should be rebuilt, when what remains of it is carried away. I have no doubt that the water of the St. Louis River will be for the greater part diverted toward the Du Luth Canal, to the detriment of the natural entrance.

My estimate of the cost of rebuilding the dike, as given in my last annual report, was \$55,000; but since then the ice has carried away a deal of the old structure, and but very little of it remains that can at all be utilized in making a new one.

A dike made of gravel, 12 feet wide at top, with side slopes of 2 horizontal to 1 vertical, riprapped along zone of wave action, would cost not more than \$87,199, and might cost less if any part of the old dike can be used. If this is to be built, the appropriation should be made specifically for it, and it should be made in one lump.

The opening made last year could still be left in the new dike, and should it prove necessary to close it at some future time, it could be fitted with flood-gates.

Arrivals and departures of vessels during the year ending December 31, 1873.

Vessels.	Arrivals.			Departures.			Value of imports.	Value of duties.	Remarks.
	No.	Tonnage.	Crews.	No.	Tonnage.	Crews.			
Steamers	228	130,502	5,117	220	129,954	5,121	\$24,358 75	\$5,090 49	Value of bonded goods, \$307,630.
Sailing vessels..	51	20,380	412	52	20,766	411	.....	.....	Duties of bonded goods, \$131,176.94.

Financial statement.

Balance in Treasury of United States July 1, 1873	\$79,636 00
Amount in hands of officer and subject to his check	51,715 75
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874	120,112 08
Amount available July 1, 1874	21,239 67
Amount required for the fiscal year ending June 30, 1876 {	
For Du Luth..	100,000 00
For nat'l entry	10,000 00
For dike.....	87,199 00

Abstract of proposals for furnishing, delivering, and leveling stone at the natural-entry piers, Superior City, Wis., opened June 20, 1874.

Names.	Residence.	Price per cord.
C. Fletcher and H. C. Henry	Minneapolis, Minn.	\$13 95
William Willard and James Mercer	Ontonagon, Mich.	5 15
Ludwig Hegardt and Nils Hall	Du Luth, Minn.	5 70
D. Schutto and W. L. McLellan	Du Luth, Minn.	5 74
A. M. Barnum	Du Luth, Minn.	6 09
Henry W. Wheeler	Ontonagon, Minn.	5 40

A 2.

ONTONAGON HARBOR, MICHIGAN.

There being no funds available for this harbor, no work was done during the year.

With the amount appropriated by the river and harbor appropriation bill, approved June 23, 1874, it is proposed to repair the inner end of the west pier and prolong it inward 430 feet, and some repairs and planking on the east pier.

This work was commenced in 1867, and the estimated cost of completing the improvement, consisting of two piers, each about 2,500 feet long, and dredging between them, was..... \$363,770 00

In 1867 there was appropriated..... \$97,600 00

In 1870 there was appropriated..... 10,000 00

Total appropriated 107,600 00

Leaving still to be appropriated..... 256,170 00

The total amount already appropriated has been expended, except \$82.41, and the following is the work accomplished:

East pier extended 1,350 feet.
West pier extended..... 224 feet.
West pier rebuilt..... 270 feet.
445 piles removed from channel.

To finish the improvement as planned will necessitate a further pier-extension of 3,425 feet, which would cost..... \$238,717 08

The repairs necessary now will cost 23,000 00

261,717 08

It will be seen that the original plans for improvement can be completed within the estimated cost, but unless the work of pier-extension can be pushed faster than the advance of the bar, the cost of making a permanently good harbor will be much in excess of the above estimate.

I would, therefore, renew my recommendation of last year, that \$150,000 be appropriated in one sum, so that the piers may be pushed out beyond the crest of the present bar.

There has been no appropriation for this harbor since 1870, and the new piers have suffered from storms, as they were not finished.

The advantages of a harbor of refuge at this point has so often been dwelt upon in previous reports, that it is unnecessary to repeat them.

It is in the collection-district of Marquette, Mich., and there is a light-house near the harbor.

Arrivals and departures of vessels during the year ending December 31, 1873.

Vessels.	Arrivals.			Departures.		
	No.	Tonnage.	Crews.	No.	Tonnage.	Crews.
Steamers	9	5,033	174	8	4,948	169
Sailing-vessels	2	100	8	2	100	8

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$82 41
Amount appropriated by act approved June 23, 1874.....	23,000 00
Amount available July 1, 1874.....	23,082 41
Amount required for the fiscal year ending June 30, 1876.....	150,000 00

A 3.

EAGLE HARBOR, MICHIGAN.

No work has been done at this harbor during the year. Plans for machinery to excavate the rock have been drawn, and are all ready for the machinist, as soon as an appropriation is made to continue the work.

The history of this work is as follows:

In October, 1866, an estimate was submitted for improving this harbor amounting to—	
For breakwater 15 feet wide.....	\$45,172 86
For excavating 1,803 cubic yards of rock.....	146,016 00
	191,188 86
There was appropriated by river and harbor bill approved March 2, 1867...	65,000 00

After a careful survey, made on the ice during the winter of '67 and '68, it was found that the above estimate of amount of rock to be removed was too small; that, for a channel 130 feet wide and 14 feet deep, it would be necessary to excavate 3,372.22 cubic yards, which made the amount necessary for completing this work \$261,293.76.

Under this estimate the breakwater was to be 20 feet wide instead of 15 feet.

From experience gained since then it has been deemed expedient to increase the width of the breakwater to 30 feet. Under contracts made in 1867 and '69 some 470 cubic yards of rock were removed, but for some reasons the contractors failed to fulfill the conditions of their contracts, and the contracts were annulled.

The following is the estimated cost to complete this work:

For excavating 2,843 cubic yards of rock, at \$50.....	\$142,150 00
For building breakwater 30 feet wide.....	68,368 77
	210,518 77
10 per cent.....	21,051 87
	231,570 64

RÉSUMÉ.

Estimate made after resurvey in 1868.....	\$261,293 76
Appropriation in 1867.....	65,000 00
	196,293 76
Present estimate	\$231,570 64
Amount on hand.....	23,208 28
Amount to be appropriated.....	208,362 26
Difference between estimates of cost.....	12,068 50
Difference in cost of breakwater 20 feet wide and 30 feet wide.....	21,332 93

Making the present estimate a trifle less, considering the difference of cost of breakwater, than the one in annual report of 1868.

If this work of improvement is to be pushed to completion, a sum of not less than \$150,000 should be appropriated in one lump, as from it the plant to do the whole work must be bought.

The work of rock excavation should be done by machinery, to be owned by the United States, and hired labor.

Eagle Harbor is in the collection-district of Marquette, Michigan. The nearest light is at Copper Harbor.

At present there is not much commerce at this place, but there would be much more if the condition of the harbor was better.

Arrivals and departures of vessels during the year ending December 31, 1873.

Vessels.	Arrivals.			Departures.		
	No.	Tonnage.	Crews.	No.	Tonnage.	Crews.
Steamers	20	9,730	346	20	9,730	346
Sailing-vessels	1	254	8	1	254	8

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$13,761 11
Amount in hands of officer and subject to his check.....	11,047 57
Amount expended during the fiscal year ending June 30, 1874.....	1,600 40
Amount available July 1, 1874.....	23,208 28
Amount required for the fiscal year ending June 30, 1876.....	150,000 00

APPENDIX B.

ANNUAL REPORT OF MAJOR D. C. HOUSTON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1874.

UNITED STATES ENGINEER OFFICE,
Chicago, Ill., September 8, 1874.

GENERAL: I have the honor to transmit herewith annual report for the works in my charge for the fiscal year ending June 30, 1874.

I am, general, very respectfully, your obedient servant,

D. C. HOUSTON,
Major of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

B 1.

IMPROVEMENT OF MARQUETTE HARBOR, MICHIGAN.

The operations at this harbor are reported as follows by Assistant Engineer W. H. Hearing, in immediate charge of this harbor:

From the records of Capt. J. W. Cuyler, Corps of Engineers, I find that during the past year the whole of the crib-work which forms the breakwater for this harbor has been covered with a decking of 3-inch plank, spiked to the cribs, as far as crib No. 37, which is the third crib from the outer or southern extremity of the structure. That the requisite quantity of stone ballast has been placed in to refill the sections of the pier from which stone had been swept by the sea, previous to the cribs being covered and secured with plank; and that superstructure has been built and completed over cribs Nos. 33, 34, 35, 36, and 37 since the date of the last annual report; and that crib No. 39, which was reported at that time as being built, has been sunk in place at the present extremity of the breakwater. Also that about 180 cords of stone have been placed as a riprap on the east side of the breakwater as a protection to the work.

The recent appropriation by Congress of \$15,000 will be applied to the construction of one crib of 50 feet in length by 30 feet in width, which will complete the breakwater as originally proposed, and to building the necessary superstructure over cribs Nos. 38 and 39.

From experience obtained when formerly in immediate charge of this work I am induced to state respectfully that no efforts or expense should be spared in its protection by placing stone of the largest obtainable size to the seaward of the structure, and having in view its stability beyond a question. I respectfully recommend that an effort be made to obtain a further appropriation of \$20,000 for the purpose, in addition to the sum of \$5,000 necessary for the completion of the superstructure over the crib which it is proposed to build and sink this season, making together the sum of \$25,000 for the completion and protection of this work.

The iron interests generally have suffered severely from the effects of the stagnation in trade, caused by the panic which occurred last year; but in proportion as confidence is restored the demand for iron will be increased, and this great market of supply will more largely than ever contribute in quantity to the demands of the country for this indispensable article.

This season it is proposed to place one more crib in extension of the breakwater, and to build the superstructure over the two cribs sunk in 1873. This will make the total length of the breakwater 2,010 feet, which is 10 feet longer than the original design. It will be necessary next season to complete the superstructure over the crib to be placed this season, to make a substantial pier-head to protect the breakwater from collisions, and to thoroughly riprap the exterior of the work.

The original estimated cost of this work was \$385,129.58, and there has been expended up to date \$276,730, leaving an excess of \$108,399.58.

It is probable that the increasing trade of this port will demand enlarged harbor facilities. The great depth of water (over 30 feet in prolongation of the breakwater) is an objection to its further extension, though this plan would probably produce the best results.

Another plan would be to build another breakwater, commencing at a point 500 or 600 feet southwest of the end of the present breakwater, and extending southward parallel to the shore.

This work, being in less depth of water, would cost much less than the extension of the present work.

No estimate is submitted for this work, but it is suggested here in case the demands of commerce should call for it.

The number of arrivals and departures of steamers and sailing-vessels during the past year are as follows:

Arrivals: Of steamers, 755; of sail-vessels, 673.	
Departures: of steamers, 755; of sail-vessels, 673.	
The tonnage-capacity of these vessels was.....	738,265 tons.
The quantity of iron-ore exported was.....	552,295 tons.
Of pig-iron exported.....	26,584 tons.
The duty collected on imports, tonnage-tax, marine-hospital tax, steam-boats, &c., was.....	\$15,060 25

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$15,000 00
Amount in hands of officer and subject to his check, (including \$2,373.83 percentage due on contracts not yet completed)	24,802 07
Amount appropriated by act approved June 23, 1874.....	15,000 00
Amount expended during the fiscal year ending June 30, 1874.....	39,192 87
Amount available July 1, 1874	15,609 20
Amount required for the fiscal year ending June 30, 1876	25,000 00

B 2.**IMPROVEMENT OF MENOMONEE HARBOR, MICHIGAN AND WISCONSIN.**

The operations at this harbor are reported as follows by Assistant Engineer W. H. Hearding, in immediate charge:

The length of the extension which was built to the south pier of this harbor during 1873, was 720.1 feet. The length of the extension which was added to the north pier was 351.9 feet. Each of these piers is 14 feet in width.

The work is of a substantial character, and was done by Mr. Abner Kirby, under his contract of date May 26, 1873. With the exception of three sections at the extremity of the south pier, together forming a length of 96 feet, the whole of the work was filled with edgings ballasted with stone.

The filling in the north pier, for a length of 256 feet, has settled to a depth of 4½ feet below the top of the superstructure, and will require refilling. The slab pier built in 1872, and of which the above is an extension, should also be ballasted with 50 cords of stone to insure its stability. A plot of the soundings recently taken by Mr. F. C. Bradley, shows that a depth of 13.1 feet of water exists at the eastern extremity of the north pier, and 4.6 feet at the outer end of the south pier. At a distance of 165 feet to the eastward, on the alignment of the south pier, the water is shown as being 13 feet in depth.

By act of Congress of date June 23, 1874, the sum of \$25,000 was appropriated for the continuation of the improvement of this harbor. During the present season, \$10,000 of this amount will be applied to deepening the channel by dredging. A contract was entered into by the Menomonee Dredging Association on the 26th day of the present month, to remove 40,000 cubic yards of material from the channel at the rate of 25 cents per cubic yard.

The rest of the appropriation will be applied to the extension of the piers, and furnishing the requisite quantity of stone ballast for perfecting the work done in 1872 and 1873. The amount available after the refilling of stone is completed, will construct 12½ feet in length, for the extension of the north pier; and in equal length for the extension of the south pier, making a total length of 256 feet of finished work.

A summary of the work proposed to be done under the available appropriation is as follows, viz:

For 70 cords of stone ballast to refill the vacancies caused by subsidence of material in north pier, at \$10.....	\$700 00
For 50 cords of stone to secure slab pier, at \$10.....	500 00
For completing three outer sections of south pier.....	2,000 00
For removing 40,000 cubic yards of material from channel, at 25 cents....	10,000 00
For constructing 4 sections, 32' by 18', extension of north pier, at \$1,182.73.	4,730 92
For constructing 4 sections 32' by 14', extension of south pier, at \$1,045.50.	4,182 00
	22,112 92
Leaving for expense of superintendence, &c.....	2,887 06
Amount of appropriation.....	25,000 00

In order to carry out the piers to a depth of 15 feet of water, and provide a channel of such width and depth as will meet the requirements of the commerce of the place, an appropriation of \$50,000 should be made to be expended during the season of 1875.

A great improvement to this harbor would probably be effected by cutting off a portion of the point which projects into the channel from the north side, which was originally the outer point on the north side of the mouth of the river, and by filling up the

angle formed by the slab pier-work of 1872, and the original dock of R. Stevenson & Co., at the mouth of the river.

The number of arrivals and departures of steamers and sailing-vessels during the year are as follows :

Arrivals.—Of steamers, 210; of sailing-vessels, 468.

Departures.—Of steamers, 209; of sailing-vessels, 468.

Of exports there have been as follows: Lumber, 122,003,529 feet, (B. M.) lath, 22,154,400; pickets, 604,953; posts, 72,381; general merchandise, 88 tons; pig-iron, 3,000 tons; fish, 11,500 packages.

Imports.—Hay, 3,000 tons; oats, 88,500 bushels; corn, 26,400 bushels; malt, 1,000 bushels; bran, 4,000 bushels; potatoes, 5,500 bushels; general merchandise, 1,310 tons; bricks, 100,000; salt, 4,000 barrels; coal, 700 tons; quarry-stone, 300 cords; mess pork, 6,200 barrels; mess beef, 1,200 barrels; dried beef, 505 barrels; smoked hams, 1,075 barrels; sirup, 500 barrels; whisky, 230 barrels; beer, 250 barrels; onions, 600 barrels; flour, 17,500 barrels; corn-meal, 1,450 barrels; oatmeal, 150 barrels; crackers, 4,500 barrels; dried apples, 2,300 barrels; green apples, 4,500 barrels; beans, 2,500 barrels; peas, 500 barrels; lime, 3,000 barrels; sugar, 4,500 barrels; plaster Paris, 100 barrels; cement, 200 barrels.

The plan adopted for the improvement of this harbor was not fixed until after the first appropriation of \$25,000 in 1871 was made. Consequently no original estimate was made. It is estimated that the total cost of the plan now being carried out, *i. e.*, extending the piers to a depth of 16 feet in the bay and dredging out a channel 14 feet deep from the mouth up to a point in the river now crossed by the ferry, is \$212,000. There has been appropriated up to date, \$100,000.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$25, 000 00
Amount in hands of officer and subject to his check, (including \$1,254.84 percentage due on contracts not yet completed).....	11, 350 01
Amount appropriated by act approved June 23, 1874.....	25, 000 00
Amount expended during the fiscal year ending June 30, 1874.....	34, 837 69
Amount available July 1, 1874.....	26, 512 32
Amount required for the fiscal year ending June 30, 1876.....	50, 000 00

B 3.

IMPROVEMENT OF GREEN BAY HARBOR, WISCONSIN.

The operations at this harbor are reported as follows by Assistant Engineer W. H. Hearing, in immediate charge :

By act of Congress March 3, 1873, the sum of \$20,000 was appropriated for the improvement of this harbor, and a contract was made with Mr. Albert Conro of Milwaukee, Wis., on the 30th of May, 1873, for widening and deepening the channel, commencing at the angle formed by the first and second reaches outside of the mouth of Fox River.

The shape of this section, which was improved by dredging, was triangular, the vertex of the triangle being situated at the angle made by the reaches as above stated, the base of the figure extending from the elbow near the mouth of the river to a distance of 150 feet to the westward of the original channel bank.

The lengths of the legs of this isosceles triangle were each 2,350 feet. The average depth of excavation was 6½ feet.

Besides the accomplishment of this work, about 5,000 cubic yards of material were removed from the channel immediately to the eastward of and adjoining this improved section. The total quantity of material excavated and removed was 49,833 cubic yards. Piles were driven to mark the alignment of the channel and for establishing the datum for governing the depth to which excavation was made.

The recent appropriation made by Congress of \$10,000 will be applied to the improvement of the channel by dredging and in repairs to the revetment of the east pier across Grass Island.

By your orders a survey of the channel was made during the latter part of February

and the beginning of March last from the mouth of Fox River to a point 2,862 feet to the northward of the northern extremity of the revetment across Grassy Island. The method adopted for taking the soundings was by cutting holes through the ice upon lines of cross-sections, which were established at parallel distances of 30 feet apart. The soundings were taken upon the cross-section lines at distances of 20 feet apart. This survey shows that an extensive bar has been formed across the channel at a point commencing at a distance of about 1,600 feet to the southward of the south end of the pier revetment across Grassy Island. It covers a section of the channel about 400 feet in length, the depth of water over it being about 11½ feet. This part of the channel should receive attention as soon as practicable. To provide a channel 100 feet in width, having a depth of 14 feet across the bar, will require the removal of about 12,000 cubic yards of material. One cut of the dredge 25 feet in width should next be made parallel with the range of the stations erected at the time of the survey, the positions of which formerly governed the west bank of the inner reach of the channel. This cut should be made to a depth of 16 feet below the established datum, and at a parallel distance of 40 feet to the eastward of the produced range line.

The average depth of required excavation upon this line is about 3½ feet; its length is 2,200 feet; the quantity of material to be removed is 9,500 cubic yards, scow measurement.

The pier forming the revetment, to the east side of the channel, across Grassy Island, was seriously injured by the ice during the past winter, the whole section to the northward of the island, 480 feet in length, having been twisted and ruptured to such an extent as to require immediate attention and repairs, as well as to be provided with protection for the future.

The size of the vessels trading at this port has increased since the improvement has been commenced, and the demands of the increasing commerce are urgent for vessels of still greater capacity than are at present employed. To provide a channel of 14 feet in depth, and 200 feet in width for its entire length, would require the removal of 140,000 cubic yards of material, which would involve a further expenditure of about \$45,000, provided it is considered expedient to give such facilities to the commerce of the place.

The number of arrivals and departures of steamers and sailing-vessels during the past years is as follows:

	Arrivals.	Departures
Of steamers.....	244	259
Of sailing-vessels	154	156
Total.....	398	415
Tonnage of vessels and steamers arriving	128,503 tons.	
Tonnage of vessels and steamers departing.....	137,472 tons.	

A list of the imports and exports at this harbor, as taken from the books of the custom-house officer, is as follows, viz:

Imports.—Merchandise, 81,512 packages; iron-ore, 26,382 tons; flour, 1,082 barrels; coal, 15,111 tons; salt, 28,604 barrels; carbon-oil, 2,641 barrels; liquor, 1,834 packages; fish, 1,405 barrels; lard, 4,320 barrels; shingles, 450,000; fire-wood, 616 cords; railroad-iron, 8,658 tons; lumber, 300,000 feet, (B. M.;) meat, 2,809 barrels; stone, 391 cords; plaster, 3,000 barrels; apples, 3,035 barrels; cement, 3,410 barrels; powder, 30 tons; paints, 58 packages; hardware, 4,573 packages; drugs, 138 packages; vinegar, 148 barrels; lime, 200 barrels; fish, 100 barrels.

Exports.—Merchandise, 10,617 packages; pig-iron, 13,344 tons; wheat, 307,432 bushels; flour, 39,693 barrels; empty barrels, 3,910; fish-kitts, 29,779; salt, 590 barrels; oak staves, 969,187 M; shingles, 102,153 M; lumber, 990,000 feet, (board-measure;) fish, 2,275 barrels; fish-barrels, 450; pork, 10 barrels; liquor, 10 barrels, and 1,278 half barrels; oats, 300 bushels; lime, 100 barrels; meat, 51 barrels; barrel-heads, 475,040 M.

An estimate of \$155,416.77, for completing the improvement of this harbor, was made in 1867 by Maj. J. B. Wheeler, Corps of Engineers. This contemplated a cut through Grassy Island and revetment of the same. This work was completed within the estimate in 1871.

There was appropriated in 1871 the sum of \$17,500, which was applied to dredging the channel between Grassy Island and the mouth of the Fox River. In 1872 I estimated that \$50,000 would be required to deepen and straighten this channel to a depth of 13 feet at ordinary low water and a width of 200 feet. The sum of \$20,000 was appropriated and expended in 1873. The sum of \$10,000 was appropriated this year. Owing to the increasing importance of this port it is considered best to make the channel 14 feet deep at low water. This will involve

an expenditure of \$45,000, in addition to what has already been expended. After this is expended, a small annual expenditure will be necessary for maintaining the channel.

Financial statement.

Balance in Treasury of United States July 1, 1873	\$10,000 00
Amount in hands of officer and subject to his check	9,726 00
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874	19,662 38
Amount available July 1, 1874	10,063 62
Amount required for the fiscal year ending June 30, 1876	25,000 00

B 4.

IMPROVEMENT OF THE HARBOR OF REFUGE AT ENTRANCE OF THE STURGEON BAY CANAL, WISCONSIN.

The operations at this harbor are reported as follows by Assistant Engineer W. H. Hearding, in immediate charge:

By act of Congress approved March 3, 1873, the sum of \$40,000 was appropriated for the protection of the entrance of the projected canal, which is in process of construction across the peninsula, and which divides the southern section of Green Bay from Lake Michigan.

The plan adopted for this protection is by constructing two piers, one on the north and the other on the south side of the proposed canal. Each of the points of the commencement of these piers is situated at a distance of 425 feet from the axis of the canal, making a distance between them of 850 feet, and which forms the base of a triangle. The angles of convergence, which the piers make with this base, are respectively $76^{\circ} 41'$ for the north pier, and $73^{\circ} 53'$ for the south pier; the point of the base used for the commencement of the north pier being a little in advance or eastward of a line drawn at a right angle with the axis of the canal.

Each of these piers when completed will extend into the lake upon the described angles, about 1,200 feet from the shore, to reach a depth of 18 feet of water.

The width of the channel between the eastern extremities of the piers when completed will be 250 feet.

The operations during the year 1873 resulted in the construction of 1,524 linear feet of pile-pier work, of 14 feet in width, or a length of 762 feet of each pier.

The piles forming the sides of the in-shore sections, each 100 feet in length, are driven at a distance of 4 feet apart, and are provided with cap-timbers. For the next outer sections, each of 150 feet in length, the piles are driven as near together as practicable, and are provided with cap timbers and ties. The remainder of the work is close-piling cut down to within a distance of one foot from the water-surface, and finished with superstructure.

There is but little stone left over the brush-filling in the sections nearest to the shore, particularly in the north pier, where the piers were not driven in juxtaposition. The piers themselves have withstood the action of the water and ice during the past winter very satisfactorily, scarcely any change being perceptible in their alignment, and no displacement having occurred.

Two of the sections of the south pier, the fourth and fifth from its eastern extremity, remained through the winter without a filling of either brush or stone, and the average depth of water over the stone filling in the outer or eastern section is $4\frac{1}{2}$ feet. The average of the depths by careful measurement from the upper plane of the superstructure timbers to the top of ballast is $4\frac{1}{2}$ feet. The piers will require to be filled to within 1 foot of the top of the superstructure, with stone of the largest obtainable size, owing to the exposed position of the piers. This will be done under the recent appropriation of \$10,000 allotted by Congress for securing and improving the work at this harbor; and also in view of the depth of water (about 15 feet) which prevails at the present extremities of the piers, one section of pier of an increased width, 32 feet in length, will be built in addition to each of them, and from the shoulders formed outside by this increase in width, guard-piles will be driven to cover and strengthen the present outer sections, and secured to the original structure with iron bolts.

No accretion has been formed along the shore, either to the northward or south-

ward of the piers, which is contrary to the effect usually produced by the construction of such works.

The loss of this effect is partially attributable to the admission of the water between the comparatively open pile-work, the ballasting of stone having been washed by the waves through the apertures between the piles, and for this reason I respectfully recommend that bowlder-stones only, of large dimensions, be used in refilling the piers, particularly at or near their intersections with the shore-line. The cost of procuring this character of stone is, of course, greater than that incident to the purchase of stone of a smaller size, but the importance of the object to be attained is more than commensurate to an increase in the cost of the material.

It is assumed that as soon as the action of the water through the piers near the shore is checked, that a sedimentary deposit, to a greater or less extent, will be made in the angles formed by the piers at their intersections with the shore-line, both at the northward and the southward of the work.

That a constant action of detrition and deposit takes place upon this section of the lake-shore, as at all other points which are exposed to the action of the waves where the material forming it is of sand or of material capable of being removed, is evident from the fact that on the inner side or between the piers an accretion has formed since they have been constructed, which is of a curvilinear shape, the greatest ordinate of concavity being at a center point of the shore between the piers, and it is also assumed that this accretion is not entirely due to the action of the waves confined within the limits of the basin after their admittance to the basin from the lake.

It is possible you may consider it best to finish this work of improvement by changing the method of construction from pile-work to crib-work, now that a depth of 15 feet of water has been reached, in which case an outlay of \$90,000 will be involved to complete the piers, \$60,000 of which could be advantageously expended during the working season of 1875.

During the month of January last a commission was appointed by the legislature of Wisconsin to examine the work which has been accomplished by the Sturgeon Bay Canal Company upon the canal, and to report upon the same, in which report the commissioners were required to state what proportion of the work was done. Their report shows that more than one-fourth of the entire work of excavation has been accomplished.

The total estimated cost of this improvement, including dredging between the piers, is \$180,000, and there has been appropriated up to date \$50,000. The amount appropriated this year was \$10,000, which will complete the work of last year, and extend each pier about 32 feet. The object of the improvement is to protect the lake-entrance of the canal now in course of construction from the head of Sturgeon Bay to Lake Michigan, a distance of 6,600 feet, which will make Sturgeon Bay a harbor of refuge easily accessible from Lake Michigan.

During the season of 1873 considerable progress was made on the canal, it being estimated by the State authorities that one-fourth of the excavation required was completed. The greater part of the work is dry excavation above the water-level. The wet excavation, or canal proper, is from the head of Sturgeon Bay, a distance of about 1,000 feet toward Lake Michigan. No work has been done the present season, owing to financial difficulties, but it was expected to commence work at the lake end.

The utility of the work being done by the Government depends entirely upon the completion of the canal. Unless the latter is completed the piers now under construction will be useless, and consequently it would not be advisable to appropriate more money unless the continued progress of the canal work is assured.

Financial statement.

Balance in Treasury of United States July 1, 1873	\$20,000 00
Amount in hands of officer and subject to his check	19,936 00
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874	37,980 55
Amount available July 1, 1874	11,955 45
Amount required for the fiscal year ending June 30, 1876	60,000 00

B 5.

IMPROVEMENT OF AHNAPÉE HARBOR, WISCONSIN.

The operations at this harbor are reported as follows by Assistant Engineer W. H. Hearing, in immediate charge:

The piles which were driven in 1872 in extension of the south pier, forming a section of 96 feet in length, and which remained during the winter of 1872 and 1873 without superstructure or filling, were provided with both superstructure and filling. In the spring of 1873, a pile-driver was built by the Government for use at this harbor, and an additional length of 175 feet was built in extension of the same pier. The work was done by hired labor, in a substantial manner, the whole of the pier being filled with brush and slabs, ballasted with stone.

During the latter part of October and beginning of November, 1873, a portion of the filling was washed out of the outer sections of the pier, but the pier itself remains intact. The entire length of this pier is $620\frac{1}{2}$ feet. No addition has been made to the north pier. The quantity of material used for filling in 1873 were, of slabs, $247\frac{1}{2}$ cords; of brush, $133\frac{2}{3}$ cords; and of stone ballast, $99\frac{1}{2}$ cords. A small portion of this filling was applied to the filling of the section of pier built in 1872, where the material had settled, and to protect the western extremities of the piers. The filling used in 1871 and 1872 was of slabs exclusively, ballasted with stone. From a survey which I made of this harbor, on the 31st day of August, 1873, the width of the channel-way at the west end of the piers was found to be $230\frac{1}{2}$ feet; at the eastern extremity of the north pier, which is 353 feet in length, the width of the same is $230\frac{2}{3}$; so that the piers may be considered as being parallel.

The spit of sand and drift-wood, which at times nearly or quite closes the river, channel at the west end of the piers, where they commenced, varies in extent and place according to the influence of storms and freshets; sometimes the channel being 50 or 60 feet in width, with a depth of from 4 to 5 feet of water; at others it is not more than 10 or 20 feet wide, with depth of from 1 to 2 feet.

Owing to the probability of there being no appropriation made for the improvement of this harbor in 1874, the citizens of Ahnapee joined in a petition to you for permission to construct a temporary pier between the piers proper, in order to confine the river-current within the limits of a channel of about 50 feet in width, so that a permanent channel of uniform depth and width may be maintained which will admit of the passage of vessels of light draught, until such times as means are provided by Congress for carrying out the piers to such a depth of water in the lake as will insure a permanent channel of sufficient capacity for the trade of the place.

This pier is to be constructed in such a manner as will admit of its being removed without difficulty or expense to the Government, and will not be detrimental to the work already accomplished by the Government.

Fifty thousand dollars will extend the piers and dredge the channel (as far as the condition of the site will admit) sufficient for the requirements of the trade of the place.

There has been no appropriation for this harbor since 1872, which would seem to indicate an intention to abandon the improvement. The original design, made by me in 1870, was an outside harbor, at an estimated cost of \$370,000. The sum of \$25,000 was appropriated in 1871, and the same amount in 1872. This was applied to the construction of two piers at the mouth of Wolf River, for the purpose of protecting the channel which it was proposed to excavate from the lake into the river. The north of these piers would form a portion of the work required for the outer harbor.

By the construction of the other pier and opening the river-mouth the wants of local commerce would be met, and accommodations be afforded for the construction of cribs required for the outside harbor. As a large amount of dredging would be necessary, a dredge was constructed in the winter of 1872 and 1873, the cost of which was divided equally between the appropriations for Two Rivers and Ahnapee.

The failure of the appropriation in 1873 left the work incomplete and not available for any purpose. It is proposed now to use a portion of the appropriation for Two Rivers Harbor at Ahnapee in dredging, thus

re-imbursing, in part, the harbor of Ahnapee for money expended in the construction of the dredge.

Financial statement.

Amount in hands of officer and subject to his check.....	\$9,380 11
Amount expended during the fiscal year ending June 30, 1874.....	8,926 06
Amount available July 1, 1874	454 05
Amount required for the fiscal year ending June 30, 1876	50,000 00

B 6.

IMPROVEMENT OF TWO RIVERS HARBOR, WISCONSIN.

The operations at this harbor are reported on as follows by Assistant Engineer W. H. Hearing, in immediate charge:

At the date of report, June 30, 1873, the whole of the piles were driven which were requisite for the extension of the piers at this harbor, as far as the available means would admit of finishing the superstructure. The length of the extension of the east pier, for which the piles were driven, was 485 $\frac{1}{2}$ feet. The length of the extension of the west pier, having piles simply driven, was 546 $\frac{3}{4}$ feet—showing a total length of extension to both piers, which have been provided with superstructure filled with brush and stone-ballast, since the date of last annual report to be 1,031 $\frac{1}{4}$ feet. The dredge which was built by the Government during the winter of 1872 and 1873 commenced operations at this harbor on July 14, 1873. The quantity of material excavated by it from the channel alongside the west pier was about 23,000 cubic yards, and 16,630 cubic yards were dredged and removed from the point which projected into the channel at the north end of the west pier, making a total amount excavated by the dredge of 39,630 cubic yards.

By your directions, at the request of the citizens of Two Rivers, I established the lines for governing the work of the construction of docks by private parties on the north side of the branches of the rivers on September 3, 1873, and about 190 feet of the dock-frontage has been substantially revetted by close and sheet-piling. At the close of the working-season of 1873 a channel into the river alongside the west pier, averaging from 30 to 60 feet in width, was provided for vessels drawing 9 feet of water.

The channel-way between the piers, being 270 feet wide, admits the heavy seas from the lake which are engendered by southerly winds.

The action of the sea upon the undredged section of the channel on the east side has been marked, the sand having been carried thereby into the dredged section of the channel and filling it to such an extent as to debar the entrance of vessels drawing more than 6 feet of water. The dredging-machine is at the present time undergoing slight repairs, which, as soon as completed, will enable her to be put into commission, and operations will be resumed under the recent appropriation made by Congress. The filling of the piers has settled in all the outer sections of the piers to a considerable extent.

An appropriation of \$50,000 for continuing the improvement of this harbor is respectfully recommended as being necessary to effect the work economically.

The number of arrivals of steamers, 454; the number of departures the same; the number of arrivals of sailing-vessels, 83; of departures, 85.

Three schooners have been built, the tonnage-register of which is 1,220 tons, and one tug-boat of 33 tons register. The building of a propeller of 600 tons is under contract.

The exports, as per list furnished by the Two Rivers Manufacturing Company, have been: Of leather, 294,203 pounds; hair, 49,160 pounds; pails, 3,240 dozen; tubs, 1,064 $\frac{1}{2}$ dozen; churns, 35 dozen; clothes-pins, 388 boxes; kannikins, 195 racks; half-bushel measures, 130 dozen; keelers, 56 nests; barrel-covers, 38 dozen; broom and mop handles, 37,300 pieces; fish-kits, 250 pieces; chairs, 2,061 dozen; bedsteads, 105 $\frac{1}{2}$ dozen; cribs, 11 $\frac{1}{2}$ dozen; fish, half-barrels, 583; fresh fish, 891 boxes; fresh fish, 89 barrels; sundries, 1,740 barrels; sundries, 1,823,363 pounds; hoops, 79,800; grain, 1,079 bushels; furniture, 302 pieces; hay, 311 tons; lumber, 6,500,000 feet, board-measure; lath, 1,750,000; ties, 5,100; cedar posts, 3,000; cord-wood, 1,800 cords; slabs, 1,700 cords; bricks, 250,000.

Imports.—Merchandise, 1,309,261 pounds; merchandise in barrels, 363,450 pounds; dry hides, 59,640 pounds; green hides, 272,100 pounds; black-walnut lumber, 32,500 feet, board-measure; pine, 340,000 feet, board-measure; white-wood, 300 cords.

The original estimated cost of this improvement, based on a survey made under my direction in 1870, was \$265,588.80. There was appro-

priated in 1871 \$25,000; in 1872, \$25,000; in 1873, \$25,000; and in 1874, \$15,000; making in all, \$90,000.

In my last annual report on this harbor I called attention to the difficulties and want of economy resulting from carrying on works of this character with such small appropriations, compared with the total cost of the work. If the amount estimated for an improvement could be appropriated at once, to be expended in a certain number of years, much better results would be obtained.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$25,000 00
Amount included in expenditures of year ending June 30, 1873, to be deducted from balance in Treasury.....	2,892 94
Amount appropriated by act approved June 23, 1874.....	15,000 00
Amount expended during the fiscal year ending June 30, 1874.....	22,055 70
Amount available July 1, 1874.....	15,051 36
Amount required for fiscal year ending June 30, 1876.....	50,000 00

B 7.

IMPROVEMENT OF MANITOWOC HARBOR, WISCONSIN.

The operations at this harbor are reported as follows by Assistant Engineer W. H. Hearding, in immediate charge:

Under his contract of date June 5, 1873, Mr. H. Freeman built and sunk four cribs, upon foundations of stone, each foundation comprised of about 25 cords of that material. The dimensions and positions of the cribs were as follows: 2 cribs in extension of the north pier, of dimensions 50 feet by 24 feet by 14½ feet, and in extension of the south pier, one crib 50 feet by 24 feet by 15½ feet, the other 50 feet by 24 feet by 14½ feet; making a total work of crib-construction to the water-surface in length 200 feet by 24 feet in width, protected at the outer ends by fender-timbers.

The total cost of three cribs and foundations, independent of contingencies for superintending the work, was \$11,206.30.

The items forming the account were as follows:

For 240 linear feet of pine timber, 12 by 18 inches, at 25 cents.....	\$60 00
For 160 linear feet of hemlock timber, 12 by 18 inches, at 15 cents.....	24 00
For 4,579 linear feet of pine timber, 12 by 12 inches, at 18 cents.....	824 22
For 11,662 linear feet of hemlock timber, 12 by 12 inches, at 15 cents.....	1,749 30
For 864 feet (board-measure) of oak timber, at \$24.00.....	20 73
For 24,870 pounds of iron drift-bolts, at 8 cents.....	1,989 61
For 447 cords of stone ballast, at \$9.00.....	4,031 49
For 16,713 linear feet of framing, at 15 cents.....	2,506 95

11,206 30

The general alignment of the cribs is fair; the outer crib of the south pier settled, however, 18 inches outwards, or to the southward, which is somewhat unfortunate, for the reason that if any deviation from the general alignment of the piers was desirable, it would have been better to have contracted rather than to have increased the width of the channel. The general tendency of all the cribs at this harbor (as is usual elsewhere) is to settle outwards and widen the channel. With the exception of the above-mentioned slight displacement the work is satisfactory, the cribs having suffered no further displacement from the storms of the past winter.

The balance remaining of the appropriation of 1873 will be applied to building superstructure over the above-mentioned cribs, and the remaining surplus will be added to the recent appropriation of \$10,000 and applied to the construction of four cribs of the same character and dimensions as were built in 1873, which will give an additional length to each of the piers of 100 running feet. The distance from the present eastern extremities of the piers to the line of 18 feet of water is 300 feet. Under the present appropriation, the distance will be shortened to 200 feet, which will involve the con-

struction of eight cribs, each 50 feet in length. The estimated cost of building and sinking these cribs in the increased depth of water is \$38,000, and for building the superstructure over the cribs to be sunk this season, and protection to the ends of the piers \$7,000, making a total of \$45,000, which could be well expended during the year 1875.

The effect of the recent panic was of serious importance to the ship-building interests which are centered at this point. For the time being, that effect, coupled with the extreme low rates offered for the freight of grain, has partially paralyzed that interest, so much so that at the present date there is but one vessel upon the stocks in process of building, while at the date of report June 30, 1873, there were seven. There has also been a stagnation in the lumber-market. The bountiful harvest of last year has somewhat increased the quantity of products exported, and manufactures are also on the increase. The number of arrivals and departures of steamers and sailing-vessels during the fiscal year has been—

Of steamers arriving, 621; of departures, 621.

Of sailing-vessels arrived, 604; of departures, 614.

Of vessels finished building, which were on the stocks at date of last report, 7.

Of vessels built entire since that date, 1; of vessels repaired, 23.

Exports.—Wheat, 328,650 bushels; flour, 29,400 barrels; feed, 1,000 tons; hay, 6,540 tons; peas, 31,000 bushels; potatoes, 13,500 bushels; butter, 84 tons; eggs, 28,000 dozen; fire-wood, 16,400 cords; telegraph-poles, 12,800; posts, 115,000; railroad-ties, 64,000; lumber, 3½ million feet (board-measure); lath, 110 millions; leather, 3,120 rolls.

It is impracticable to obtain an account of the quantity of merchandise imported.

The benefit of this harbor to the general commerce of the lakes was fully demonstrated during the severe gales of October and November last, as many as 150 vessels of all sizes having sought shelter in it during the prevalence of one storm.

The original estimate for this harbor, as appears from the report of the Chief of Engineers for 1866, was \$141,747.82, and a subsequent addition of \$31,000, (see Report of Chief of Engineers for 1869, page 26,) making in all \$172,747.82. According to this estimate the piers were to be extended to a depth of only 12 feet of water.

There was appropriated in 1866.....	\$52,000
There was appropriated in 1867.....	45,000
Allotted from appropriations for 1868.....	17,500
Allotted from appropriations for 1869.....	18,000
Appropriated in 1870.....	20,000
Appropriated in 1871.....	11,000
	163,500

In 1872 I submitted an estimate of \$75,431.72 for extending the piers to a depth of 18 feet. In 1873 an appropriation of \$20,000 was made, and in 1874 of \$10,000, leaving \$45,000 to complete the work, \$25,000 of which may be expended to advantage during the fiscal year ending June 30, 1876.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$20,000 00
Amount in hands of officer and subject to his check.....	3,635 02
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	13,794 24
Amount available July 1, 1874.....	19,840 78
Amount required for the fiscal year ending June 30, 1876.....	25,000 00

B 8.

IMPROVEMENT OF SHEBOYGAN HARBOR, WISCONSIN.

The operations at this harbor are reported as follows by Assistant Engineer W. H. Hearding, in immediate charge:

At the date of report, June 30, 1873, Mr. Edward Gillen, of Racine, under his contract of date January 15, 1873, had completed the superstructure over the five cribs of

the north pier, which were sunk by Mr. Knapp, under his contract of date June 17, 1871, and had also built and sunk the 50 feet by 30 feet crib at the extremity of the north pier.

Subsequently to the date of that report Mr. Gillen built and sunk the 50 feet by 30 feet crib at the extremity of the south pier, and built the superstructure over the two cribs sunk in extension of this pier in 1871.

Both of the outer cribs were set upon foundations, each formed of about 25 cords of stone. These foundations have produced the desired effect of keeping the cribs in their proper alignment and position, the cribs not having moved since they were first placed. The workmanship upon these cribs and the material used in their construction were of the best quality and character.

Under the same contract Mr. Gillen removed 5,000 cubic yards of material from the bed of the channel between the piers by dredging, so that a channel of from 50 to 75 feet in width and 13 feet in depth was provided for vessels entering this harbor in 1873. But on comparing a plat of soundings which were taken between the piers by Mr. J. O. Thayer, United States engineer foreman, on the 7th day of April, 1874, with a plat of the soundings which he took in the channel on the 11th of October, 1873, it was found that an unfavorable change had been effected in the depth of the channel. It is assumed that this change must have been caused through the action of the sea upon the channel-bed between the piers at their outer extremities and upon the banks which remained on either side of the cut when the dredging in 1873 was completed, for the depth of the water at the outer points is now greater than when the soundings were taken in October, and the channel-banks have deeper water over them, but the channel itself which was dredged is now almost obliterated. The inference is that the sand forming the bed at the outer end of the channel has been removed by the sea and carried and deposited in the west section of the channel, the sand also having run into the channel from the banks on the sides of the cut.

A part of the \$10,000 made available under the appropriation of March 3, 1873, was applied to cutting down below low-water mark 288 feet of the old superstructure of the north pier, near its western extremity, and rebuilding the same. This work was done by hired labor and purchase of materials.

The cost of doing the work in this manner contrasts favorably with the sum which it would have cost provided it had been done by contract at the prices paid under former contracts.

To have done the work by contract, at the prices paid to Mr. Gillen, the cost would have been	\$5,205 56
The actual cost of the work done by hired labor and purchase of materials was	3,670 97

So that a saving was effected of..... 1,534 59

The total expenditure at this harbor during the working-season of 1873, besides contingencies for superintendence, &c., was therefore—

For work and materials under contract of Mr. Gillen	\$15,571 24
For work and materials by hired labor and purchase	3,670 97

Total

19,242 21

The balance of the funds available from the appropriation of 1873 will be applied to building the superstructure and protecting the same over the cribs which were built and sunk under the contract of Mr. Gillen in 1873, and in the purchase of stone ballast to complete the filling of the rebuilt superstructure.

The appropriation of \$10,000 recently made available will be applied to deepening the channel, by dredging, to a depth of 16 feet of water.

The timbers of the superstructure of the older sections of the piers are becoming tender, and in a year or two will require to be cut down and rebuilt for a length of 500 feet. This would cost, with the requisite quantity of stone filling, (the stone having settled to the water-surface,) approximately, \$12,000, which sum should be appropriated for this purpose, to be used in 1875.

In this connection it may not be improper to remark that the pine timber which was used for superstructure at this harbor in 1868 is already showing signs of decay, while the oak timber which was used for the superstructure over the section of pier built by the county of Sheboygan in 1856 (twelve years previous) is yet doing duty, although of course decayed and needing replacement.

From this fact, as well as from observations elsewhere, it is to be inferred that oak timber for any purpose, and under almost any circumstances, is a superior timber to pine in large structures.

The number of arrivals and departures of steamers and sailing-vessels during the past year is as follows :

	Arrivals.	Departures.
Of steamers.....	718	717
Of sailing-vessels.....	312	322
Totals.....	1030	1039

Of sailing-vessels built or rebuilt during the year, 5; of steamers, (tugs,) 2. Total number of vessels built or rebuilt, 7.

By such information as can be derived from the transportation companies and merchants, the following is a list of the imports and exports:

Imports.—Tan-bark, 670 cords; salt, 12,000 barrels; cement, 500 barrels; coal, 6,870 tons; lumber, 7,500,000 feet, board-measure; iron, 670 tons; plaster, 6,400 tons; hides, 112,000 pounds; merchandise, 37,000 packages.

Exports.—Wheat, 408,500 bushels; packing-barrels, 33,000; peas, 47,000 bushels; chairs, 98,721; fish, 570,000 barrels; brick, 2,500,000; lime, 17,000 barrels; eggs, 75,000 dozen; cheese, 152,000 pounds; wool, 132,000 pounds; flour, 54,611 barrels; potatoes, 1,000 bushels; hay, 470 tons; cattle, 420 head; leather, 247,000 pounds.

The original estimate for this harbor, in the Report of the Chief of Engineers for 1866, was \$57,956.83, for an extension of the north pier 128 feet, the south pier 320 feet, and dredging to a depth of 12 feet.

There was appropriated in 1866.....	\$47,598 91
There was appropriated in 1867.....	8,000 00
Allotted from appropriation of 1869.....	15,000 00

70, 598 91

In 1867 (see Report of Chief of Engineers for 1867, page 22) a further improvement was recommended to extend the piers across the bar, at an estimate of \$49,000, making total estimate \$106,956.83.

There was appropriated 1870.....	15,000 00
There was appropriated 1871.....	15,000 00
There was appropriated 1872.....	18,000 00
There was appropriated 1873.....	10,000 00
There was appropriated 1874.....	10,000 00

Total amount appropriated..... 138,598 91

To explain this excess of expenditures over the estimate, amounting to \$31.642.08, there has been built 1,188 feet of pier and 64 feet over-cribs, that were carried away in the fall of 1869, instead of 864 feet, as estimated by Colonel Wheeler in the two estimates above referred to. In addition, there have been repairs to old work, amounting to nearly \$4,000. The end crib of the pier at this harbor is large, 30 feet wide and 50 feet long. My estimate of last year, of \$20,000, was designed to complete this harbor for the present, and as but \$10,000 was appropriated, and the contingent expenses are the same for a small as a large appropriation, I submit an estimate of \$12,000.

This is a very troublesome locality, the bottom of the lake being composed of fine, loose sand, constantly changing.

When the pier-extension was commenced there were 17 or 18 feet of water at the present harbor-mouth; now there are only 14½ feet, and outside a bar has formed with but 13 feet. This bar may be removed by some future storm. It seems now that no future extension of the piers will be necessary, but that the bar which may form at the harbor-mouth should be removed by periodical dredging.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$10,000 00
Amount in hands of officer and subject to his check.....	17,506 89
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	21,496 09
Amount available July 1, 1874.....	16,010 80
Amount required for the fiscal year ending June 30, 1876.....	12,000 00

B 9.

IMPROVEMENT OF PORT WASHINGTON HARBOR, WISCONSIN.

The operations at this harbor are reported as follows by Assistant Engineer W. H. Harding, in immediate charge :

Under a contract entered into by Mr. Albert Conro on the 30th of May, 1873, four cribs were built and placed in extension of the piers, one crib of dimensions 50 by 14 by 15½ feet, and one of 50 by 20 by 16½ feet, forming the north pier extension, and two cribs of like dimensions forming the south pier extension.

This work was done in a satisfactory manner. The crib-piers are each in length 420 feet. Fifty-six piles were driven for the dock-alignment upon the north side of the basin. The town authorities finished the dock across Franklin street in a creditable manner, and the whole dock is finished with superstructure to a distance of 160 feet westward of the street. Two hundred and six feet of sheet-pile dock were built in extension of the south pier, running west and parallel with the north dock of the basin.

An agreement was also made with Mr. Conro, under which he furnished a dredging-machine, two dump-scows, tug-boat, fuel, labor, and all appliances necessary to do the work of dredging, and for the removal of the material dredged, at the rate of \$150 per diem, of ten hours' actual work. This machine took out 13,992 cubic yards from the basin and between the piers, and in preparing the lake and river beds for the reception of the cribs and sheet-piling. With the stage of water at mean lake-level, a channel of about 50 feet in width was made available for vessels drawing more than 9 feet of water by keeping close to the north pier. It was considered advisable not to throw up a bank to prevent the water of the Sauk River from making its *debouchure* from between the piers, so that the effect of the deposit by river-freshets might be ascertained, and, in consequence, a deposit has been made in the basin, and also an obstruction by deposit has been formed in the channel, so that at the present time the presence of one or two banks prevents vessels having a draught of over about 6 feet of water from obtaining access to the inner docks.

A deposit of sand has been made upon the lake-bed to the eastward of the piers, in the direction of the channel, there being a depth of but 8½ feet of water upon the alignment of the northern pier, at a distance of 100 feet from its outer end, where a depth of 10 feet was found at the time of the survey in 1869; and upon the south pier alignment, at a distance of 150 feet to the eastward of its present extremity, a depth of 8½ feet, where 11½ feet was found in 1869, showing that a sand-deposit of 1½ feet in thickness has been made on the alignment of the north pier, and more than 3 feet upon that of the south pier, the stage of water being referred to the original datum. The total cost of these three characters of work was as follows :

For 200 running feet of crib-pier extension	\$9, 429 36
For 56 piles, and driving the same on line of north pier dock	498 40
For 206 running feet of sheet-pile dock, south side basin	2, 465 33
For 52,100 days' work of dredging-machine, tug, scows, &c	7, 910 25
Total	20, 303 34

The recent appropriation of \$10,000 will be applied to the construction of 200 feet of pile-revetment in continuation of the south dock of the basin, and in dredging the channel and basin in preparing for the construction of the proposed extension of south dock.

In order to do this work economically, the sum of \$50,000 should be made available in one appropriation.

This amount would enable the three characters of work to be constructed at the same time, and the result of such an expenditure would afford the citizens of the place all necessary accommodation to meet the requirements of trade for several years.

Number of arrivals of steamers, 680; of sailing-vessels, 264.

Number of departures of steamers, 680; of sailing-vessels, 263.

Of exports there have been: Quarry-stone, 258 cords; shooks, (hogsheads,) 6,230; fire-wood, 2,500 cords; hay, 400 tons; lime, 3,400 barrels; brick, 600,000; pork, 8,500 barrels; wheat, 249,250 bushels; flour, 3,000 barrels; malt, 50,000 bushels; potatoes, 20,000 bushels; butter, 1,500,000 pounds; eggs, 7,000 barrels; peas, 400 bags; white-clover seed, 32 bags; snut-machines, 6; fresh fish, 236 boxes; salt fish, 336 packages; hams, 50 barrels; cows and calves, 300.

Imports.—Lumber, 8,500,000 feet, board-measure; lath, 2,250,000; shingles, 1,500,000; salt, 500 barrels; bark, 350 cords; coal, 400 tons; iron, 500 tons; molding-sand, 150 tons; land-plaster, 500 tons; reapers, 225; seeders, 68; horse-rakes, 41; stoves, 325; merchandise, \$46,000.

There have been 44 buildings of all kinds erected. Commerce, including all branches of business, has increased. Real estate is steadily increasing in value.

The original estimate for this harbor was \$154,527.17, and there has been appropriated up to date \$70,000, not exceeding \$15,000 in any one year.

Although the work is very satisfactory, it is done at a great disadvantage on account of the small appropriations.

Financial statement.

Balance in Treasury of United States July 1, 1873	\$15,000 00
Amount in hands of officer and subject to his check	7,442 78
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874	21,804 64
Amount available July 1, 1874	10,638 14
Amount required for the fiscal year ending June 30, 1876	50,000 00

B 10.

IMPROVEMENT OF MILWAUKEE HARBOR, WISCONSIN.

The operations of this harbor are reported as follows by Assistant Engineer W. H. Hearding, in immediate charge:

The piers at this harbor being carried out to a sufficient depth of water for the present requirements of navigation, the sum of \$10,000, which was appropriated by act of Congress of March 3, 1873, was applied to dredging between the piers, and from the survey made in November, 1872, it was estimated that this sum would be sufficient to provide a channel of 200 feet in width, having a depth of 17 feet of water for the entire length of the straight cut. In making this estimate no allowance was made (as it could not well be) for a further accumulation and deposit of sand or other material from extraneous sources, but was simply confined to an estimate of the quantity of material then in place between the piers, and which required removal in order to provide a channel as described. It is highly probable that periodical dredging will be required at this harbor to free the channel from sedimentary deposit. The chief source from which this deposit is derived is from the beach to the northward of the piers, and the operation of deposition is effected during seasons of dry weather.

The sand forming the beach being dry is readily taken up by northwest winds, and carried over the north pier and deposited in the channel; this action has often been observed and commented upon by persons frequenting the vicinity.

The second source of supply is from the action of the sea upon the lake-bed outside of the piers, the sand being distributed thereby and carried into the channel.

The third source is that of the sewage-matter which is produced in no inconsiderable quantity from a manufacturing city containing 100,000 inhabitants or thereabouts. The soundings which were taken in the channel during the latter part of November, 1873, at a low stage of water, after the dredging was completed, revealed the presence of a bank having but 14 feet of water over it in mid-channel, at a distance of about 100 feet to the eastward of the light-house, and upon which several heavily-laden vessels struck when entering the harbor. The plat of soundings which were taken in April, of this year, shows a good depth of water in the channel, excepting the presence of the before-mentioned bank, and as the stage of water is higher this season than it was last year, I have heard no complaints of the shallowness of the water.

The appropriation of \$10,000, which is now available, will provide a sufficient depth of water for the purposes of navigation at present.

The depth of water in the channel at the present time contrasts very favorably with that which existed in 1869, before the extension of the piers was completed.

At that time a bank extended entirely across the mouth of the channel which carried less than 12 feet of water over any portion of it, and over a large section of its area but 10 $\frac{1}{2}$ feet of water existed. This fact shows the benefit which the city of Milwaukee, and commerce in general, has derived from the expenditure which has been made by the United States Government at this point.

Were the channel to revert to the condition in which it was during 1869, and

previous to that date, the whole commerce centering at this point would become paralyzed.

Having in view the necessity for rebuilding the superstructure of the inner sections of the piers at an early date was one reason for not recommending an appropriation to be made for the year 1874.

The necessity of this reconstruction is now imperative, and, having in view prospective economy and permanent durability, I respectfully submit a plan, with bill of materials required for rebuilding the superstructure over the inner sections of the piers with "cut-stone masonry."

These sections of piers were built during the years 1856 and 1857, and the cribs forming them may be considered as having effected as permanent a settlement as they will assume; but as all works of this character are periodically exposed to storms of such extraordinary violence as to be capable of disturbing stone which has been simply used and thrown in the cribs as ballast, and which may have remained immovable in their positions in the cribs during the preceding storms of many years, I have provided a base of solid timbers for the side and cross walls of the superstructure to rest upon, and to which the lower courses of stone are to be fastened by means of bolts, so that disruption to the masonry may be averted, even though the loose ballast should be disturbed by such extraordinary action.

The upper plane of these timbers is intended to be at a depth of 1 foot below the plane of low water.

The method of constructing the base for the masonry to be as follows:

As soon as the old work is cut down and leveled for their reception, the timbers forming the base can be fastened together in sections with screw-bolts, and floated to and over the positions which they are to occupy upon the substructure, and securely fastened with drift-bolts to the same. This can be done with facility.

It is expected that the timbers forming the base will impart additional strength to the substructure.

The following is an estimate of the rebuilding with cut stone one section of pier of 32 feet in length by 20 feet in width:

For cutting down 1,100 linear feet of old timber, and removing stone ballast in cribs, at 6 cents	\$66 00
For 352 linear feet of framed timber, at 40 cents	158 40
For 9 cords of stone ballast, at \$11	99 00
For 2,934 $\frac{1}{2}$ pounds of wrought-iron drift-bolts, cramps and dowel's, at 5 cents	146 71
For 194 pounds of screw-bolts, at 10 cents	19 40
For 672 pounds of lead, at 5 cents	33 60
For 2,128 cubic feet of cut stone, (laid,) at \$1.50	3,192 00
For 13 barrels of cement in béton of top course, dimensions 26' $\times$ 12' $\times$ 14', at \$2.25	29 25
For 4 yards of sand and gravel, at 80 cents	3 20
For labor of laying béton for one section	10 00
Cost of one section	3,757 56
Number of cribs in old work of north and south piers	70
	263,029 20
Add 10 per cent. for contingent expenses	26,302 92

Estimated cost of 70 sections

289,332 12

The number of arrivals of steamers and sailing-vessels during the past year has been 8,447, having a tonnage register of 3,109,189; of departures, 8,331, with a tonnage register of 3,023,422 tons.

The amount of duty collected during the fiscal year has been \$192,442.63.

This harbor may be regarded as completed at present, so far as the extension of the piers is concerned. Periodical dredging will be required to maintain the channel, amounting to an average of \$5,000 per annum.

It is necessary, however, to replace the old superstructure built in 1856 and 1857, and it is recommended that this be done with stone masonry, in accordance with the plan submitted herewith.

The total estimated cost of replacing 2,240 feet of superstructure is \$300,000, and an estimate of \$100,000 is submitted for the next fiscal year.

In 1867 an estimate was submitted to extend the piers at this harbor 300 feet each, at an estimated cost of \$65,872.80.

It was found necessary to extend the piers much farther and in greater depth of water.

There was appropriated in 1866.....	\$48,283 17
Allotted in 1869.....	35,640 00
Appropriated in 1870.....	40,000 00
Appropriated in 1871.....	38,000 00
Appropriated in 1873.....	10,000 00
Appropriated in 1874.....	10,000 00
	181,923 17

The cost of the pier-extension, 600 feet to each pier, in from 16 to 18 feet depth of water, 25 feet wide, except the 50 feet at the outer end, which is 30 feet wide, and including some repairs caused by collisions, &c., is \$161,923.17. The sum of \$10,000 was applied to dredging last year, 1873, and the present appropriation of \$10,000 will be applied to the same purpose.

Financial statement.

Amount in hands of officer and subject to his check.....	\$10,000 00
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	9,568 73
Amount available July 1, 1874.....	10,431 27
Amount required for the fiscal year ending June 30, 1876.....	100,000 00

B II.

IMPROVEMENT OF RACINE HARBOR, WISCONSIN.

The operations at this harbor are reported as follows by Assistant Engineer W. H. Hearding, in immediate charge:

During the working-season of 1873 the north pier at this harbor was extended 100 feet into the lake by building and sinking two cribs upon foundations of stone, each being of dimensions 50 by 30 by 18½ feet, which brought them to a height of 1 foot above the water-surface at the time of setting. This work was done by Mr. F. M. Knapp, under his contract of May 29, 1873.

The direction in which the cribs are set is due east from the former extremity of the pier. The materials used and work done upon them are of the best character. Soon after they were sunk they were covered with a decking of 3-inch plank, firmly spiked to the cribs, to act as a preventive against the washing-out of the stone by the sea. During the past winter the greater part of this covering was carried off from the outer crib by the sea and ice. The covering of the inner crib was but little disturbed.

As at other points, the stone foundations have performed the duty of keeping the cribs from tilting to a serious extent.

The direction of the outer reach of the north pier, built previous to 1873, was east by north, so by sinking the two cribs upon an east and west alignment, an angle was formed at the jointure of the new work with that previously built. The opening made at this jointure on the outer side of the pier by the change in direction, was closed by the insertion of a frame of timber sheeted with plank and bolted to both the old and new work.

The interval between the cribs was filled with brush ballasted with stone, as was also the interval at the angle between the old and new work. Timbers were bolted to the extremity of the outer crib to protect it from rupture through collision.

A mat made of 2½ cords of brush, having 6 cords of stone ballast placed upon it, was put into the crib next to the westward of the light-house crib, where the stone formerly put in as ballast had run through the grillage-work into the channel-bed, leaving one section of the crib entirely without ballast.

An agreement was also made with the Racine Dredging Company to dredge and remove material from between the piers. The price paid for doing this work was 27½ cents per cubic yard, under which agreement 16,773 cubic yards of material were removed, resulting in the providing of a channel of 14 feet in depth and about 120 feet in width for the whole of the distance between the piers. The total amount paid for materials and labor in doing the above work was \$17,452.87.

The appropriation of \$10,000 was made by Congress in June, 1874, will be applied to finishing the two cribs built last year with superstructure and filling the same with stone ballast, and in building and sinking one crib in extension of the north pier to the water-surface.

It is assumed that, with the addition of this crib, the piers will not require further extension at present. Dredging to the extent of 25,000 cubic yards should be done to provide a sufficient depth of water for the entire length and width of the channel, which, at 27½ cents per yard, would cost..... \$6,875 00
 And for building superstructure over the crib to be built this season..... 2,000 00

To which add 10 per cent. for superintendence, &c..... 8,875 00
 887 50

Will make a sum necessary to be expended..... 9,762 50
 in 1875, and which amount is respectfully recommended as an appropriation.

Number of arrivals of steamers, 410; departures the same. Number of arrivals of sailing-vessels, 600; departures the same. Aggregate tonnage, 323,709.

It has been impracticable to obtain an account of the manufactures and general commerce of the place, so that but a partial list of exports and imports is appended as furnished by Mr. H. Griswold, deputy collector of customs.

Marine imports for the fiscal year ending June 30.—Lumber, 30,067,000 feet, board-measure; laths, 1,883,000; shingles, 4,477,000; fire-wood, 13,137 cords; slabs, 336 cords; tan-bark, 1,780 cords; coal, 32,594 tons; cedar posts, 56,095; salt, 15,738 barrels; railroad-ties, 31,208; pig-iron, 900 tons.

Marine import.—Wheat, 138,521 bushels; flour, 533 barrels; oats, 4,803 bushels; pork, 191 barrels; potatoes, 216 bushels; hay, 567 tons; corn, 1,600 bushels.

The above list does not show one-fourth of the trade of the city of Racine.

One manufacturing establishment alone doing an annual business of \$1,500,000.

The original estimate for this harbor, made in 1866, was \$108,082.48. It was proposed with this sum to extend the north pier 400 feet and the south pier 656 feet, and dredging to the amount of \$11,040.70.

There has been in 1866.....	\$23,910
In 1867.....	45,000
Allotted in 1869.....	22,500
In 1870.....	10,000
In 1871.....	10,000
In 1873.....	20,000
In 1874.....	10,000

141,410

In 1869 I see that the estimate for completion was increased to \$131,410, owing to the loss of a crib and repairs not estimated for. It has been found necessary to extend the north pier 134 feet farther than originally designed, and to increase the size of the cribs.

The estimate of \$15,000, submitted last season, was designed to complete the pier-work at this harbor for the present. The appropriation being only \$10,000, the sum of \$5,000 more is required for this purpose.

The sum of \$5,000 is also estimated for dredging to put the harbor in good condition.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$20,000 00
Amount included in expenditures of year ending June 30, 1873, to be deducted from balance in Treasury.....	88 00
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	19,520 40
Amount available July 1, 1874.....	10,391 60
Amount required for the fiscal year ending June 30, 1876.....	10,000 00

B 12.

IMPROVEMENT OF KENOSHA HARBOR, WISCONSIN.

The operations at this harbor are reported as follows by Assistant Engineer W. H. Hearding, in immediate charge:

During the month of July, 1873, superstructure was built over the 50 by 30 foot crib, which was sunk in extension of the north pier, in 1872, by Mr. Knapp, under his contract of date August 10, 1872.

There being no appropriation made for this harbor in 1873, the above-mentioned work was all that was done, with the exception of the purchase of 29 cords of stone necessary to be placed in the section of repaired superstructure at the east end of north pier, and which exhausted the available means, the expense involved being \$3,159.98.

The recent appropriation of \$10,000 will be applied to the construction and sinking of one crib of dimensions 50 by 30 feet to a height of 1 foot above the water-surface, in extension of the north pier. The storms which occurred in March last effected a good deal of damage to the old work immediately to the westward of the beacon-light, and whatever surplus remains after the crib is built and sunk will be applied to the purpose of arresting, as far as possible, further damage to this section of the pier.

The city authorities have dredged in the channel between the piers to a certain extent, and have somewhat increased the depth of water, but in order to provide a channel of sufficient capacity to admit of the passage of vessels of a large class, which are now debarred an entrance to the harbor, a further appropriation of \$14,000 is requisite, which will provide a depth of 16 feet of water.

It is also desirable that an additional crib of 50 feet in length and 30 feet in width be placed in extension of the north pier, and that repairs be made to the older sections of the piers.

An estimate of the cost of doing this work is as follows:

For superstructure to crib to be built under the present appropriation	\$3,500 00
Dredging to provide 16 feet of water.	14,000 00
For one crib in extension of north pier	10,000 00
For repairs to old work	2,500 00
	30,000 00

This sum is respectfully recommended for appropriation, to be used in the improvement of this harbor during the year 1875.

The following list of exports and imports, &c., has been kindly furnished me by Mr. Wallace Mygatt, former United States engineer, foreman at this place:

The number of arrivals of sailing-vessels during the fiscal year has been 328; the number of departures, 351. The tonnage-register of vessels belonging to Kenosha is 9,859 tons.

Exports, (marine).—33,991 bushels oats; pork, 352 barrels; flour, 1,029 barrels; hams, 17 barrels, and 6,000 pounds loose; corn-meal, 3½ tons in bulk, and 15 barrels; feed, 52 tons; potatoes, 1,280 sacks; butter, 342 firkins and 5,000 pounds; gravel, 76 yards; steam-boilers, 3; steam-pumps, 1; salt, 84 barrels; lumber-wagons, 13; trucks, 10; corn, 71 bushels; eggs, 11 cases and 15 barrels; coal, 10 tons; cheese, 952 boxes and 2,000 pounds; bricks, 450,000; cows, 1; yokes of oxen, 11; wagon-skeins, 77 sets; malt, 107,000 bushels; stone ware, 3,000 pounds; rags, 408 sacks; scrap-iron, 17 tons; apples, 119 barrels; iron castings, 1,108 tons; tubing, 193 pieces; pumps, wooden, 123; crackers, 403 barrels; cedar posts, 6,000; leather, 1,952 rolls; ice, 25 tons; neck-yokes, 632; matches, 1,428 cases; barley, 221 bushels; hair, 62 sacks; blankets, 1 bale; wool, 120,110 pounds; flaxseed, 3,530 bags; hemp, 517 bales and 510 pounds; fresh fish, 1,247 tons; hay, 1,350 tons; pig-iron, 66 tons; nuts, 158 sacks; tallow, 67 barrels; pianos, 2; sheep-skins, 53 bales; cider-barrels, 103; lumber, 174,000 feet, (board-measure).

Imports.—Iron axles, 9 tons; wagon-springs, 10 tons; wagon-hubs, 169 packages; fire-brick, 1,000; hides, 586 packages; hides, 4,725 pounds; salt, 2,217 barrels; cement, 71 barrels; water-lime, 290 pounds; building-stone, 189 cords; dressed stone, 40 tons; scrap-iron, 95 tons; flour, 1,105 barrels; pig-iron, 1,732 tons; lumber, 13,536,000 feet, (board-measure;) hard wood for wagon-manufacture, 1,897,500 feet, (board-measure;) coal, 8,244 tons; bar-iron, 871 tons; bricks, 35,000; barley, 38,000 bushels; shingles, 2,375,500; staves and heading, 10,000 pieces; feed, 80 tons; fire-wood, 5,507 cords; tan-bark, 1,250 cords; cedar posts, 15,000; sheet iron, 11 tons; lath, 950,000 feet; grind-stones, 2 tons; piano-fortes, 1; apples, 150 baskets; pears, 150 baskets; grapes, 220 baskets; peaches, 790 baskets; hay, 6 bales.

In the Report of the Chief of Engineers for 1866, Ex. Doc. No. 56, Part 2, House of Representatives, Thirty-ninth Congress, second session, page 118, I find an estimate for pier extension and dredging of \$55,150.55. There was at that time an appropriation of \$75,461.41.

In 1867 there was asked an additional appropriation of \$40,000 for dredging and repairs to piers.

In 1868 a further estimate was submitted of \$70,000 for additional piers, extension, and dredging.

In 1869 the estimate for 1867 was renewed.

There has been appropriated in 1866.....	\$75,461 41
Allotted from appropriation for 1869.....	5,346 00
Appropriated in 1870	10,000 00
Appropriated in 1871	10,000 00
Appropriated in 1872	10,000 00
Appropriated in 1874	10,000 00
	110,807 41

It would appear that the original estimate is obtained by adding to the appropriation of 1866 the estimate submitted in 1868, which would be \$145,461.41. It appears that there was one crib lost in 1867 after being paid for. Another crib was broken and lost in 1871.

The estimate now submitted of \$30,000 is to be applied to extending the north pier 50 feet, repairing the old work on the north pier, and in dredging. This will not exceed the above estimate, and it is believed to be necessary for the preservation of old work and the proper maintenance of the harbor. Future appropriations will be necessary from time to time.

Financial statement.

Amount in hands of officer and subject to his check	\$507 94
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	371 35
Amount available July 1, 1874.....	10,136 59
Amount required for the fiscal year ending June 30, 1876.....	30,000 00

B 13.

IMPROVEMENT OF CHICAGO HARBOR, ILLINOIS.

The operations at this harbor are reported as follows by the assistant in immediate charge, First Lieut. F. A. Hinman, Corps of Engineers:

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., May 13, 1874.

SIR: The operations at Chicago Harbor, from the close of the fiscal year ending June 30, 1873, to December 19, 1873, (the date of my being relieved from duty under your orders,) were as follows:

Replacing a few protection piles carried away by the ice at the northeast corner of the breakwater; repairing damages done to the breakwater by vessels, and also in extending the breakwater southward 1,100 feet, excepting the superstructure, as contemplated in my last annual report. This work was done by Messrs. Fitzsimmons & Cornell, of Chicago, Ill., under contract dated May 27, 1873. The contract for this work would have expired August 1, 1874; it was closed December 5, 1873, the money appropriated for the work being nearly exhausted. In less than six months the above-named firm built and sunk 22 cribs, each 50 by 30 feet. Nine of these cribs were of the usual height, 18½ feet; the remainder were built 2 feet lower, the stone foundations having been correspondingly raised. In December last the latter cribs stood quite as well as the former. Their cost, in round numbers, including cost of foundation and filling, was \$70 less per crib than the same for the others.

To complete the outer harbor as designed will require a further extension of the breakwater of 150 feet, and the building of the superstructure over 2,050 feet, besides the construction of a south pier (about half a mile in length) from the southern end of the breakwater to the shore. For the reasons given in your last annual report, it is still a question whether the south pier should be built.

During July and August the harbor was very accurately resurveyed by assistant John Pierpont and myself, assisted by Mr. R. S. Littlefield, the United States engineer foreman. The survey embraced that portion of the harbor lying within the prolongation of Van Buren street, (the line of the proposed south pier,) the line of the lake tunnel, the 25-foot curve, the shore line, and a line drawn across the river near the Illinois Central Railroad elevators.

The survey disclosed few important changes, except that the shore line north of the north pier was advancing. It is believed that vessels find plenty of water in that portion of the river covered by the survey.

During the survey two wrecks were discovered and located. They consisted of a dump-scow and a schooner, and were lying in the basin near the return of the breakwater, with 8 feet of water over them. Estimates for the removal of these wrecks, for the completion of the breakwater, and for the extension of the north pier 400 feet, were submitted in your last annual report.

Extensive dredging is still being carried on here and there in the outer harbor, by private parties, for sand for building purposes, and also for material for filling the piers now being built by the Illinois Central Railroad Company north of Randolph street.

Respectfully submitted.

F. A. HINMAN,
First Lieutenant of Engineers, U. S. A.

Maj. D. C. HOUSTON,
Corps of Engineers, U. S. A.

I was relieved from the charge of this harbor by paragraph 2, Special Orders No. 140, War Department, Adjutant-General's Office, dated Washington, June 26, 1874.

The original estimate for the work now under construction, viz, an outside basin or harbor, was \$867,095.73. See Report of Chief of Engineers for 1870, page 103, as follows:

For the eastern breakwater, 4,000 feet in length.....	\$602,252 00
Outer half of southern breakwater, 1,700 feet in length.....	167,418 38
Inner half of southern breakwater.....	97,425 35
And for dredging.....	867,095 73
	30,000 00
In round numbers.....	900,000 00
There was appropriated in 1870.....	\$100,000 00
There was appropriated in 1871.....	100,000 00
There was appropriated in 1872.....	90,000 00
There was appropriated in 1873.....	90,000 00
There was appropriated in 1874.....	75,000 00
	455,000 00

This will complete the eastern breakwater, including 300 feet of return on north end, at about three-fourths of the estimate.

The question of building the southern breakwater was discussed in my last annual report. It should not be undertaken until the question of occupying the lake-front for wharves is definitely settled.

In my last annual report I submitted an estimate for extending the north pier, which I consider of more immediate importance to this harbor than any other work. The estimate for this purpose is \$78,000.

The following statements concerning the commerce of Chicago, kindly furnished me by Mr. John Hitt, special deputy collector of the port, are respectfully submitted:

CUSTOM-HOUSE, CHICAGO, ILL.,
Collector's Office, August 21, 1874.

SIR: I have the honor to transmit herewith the statement of the number of vessels entered and cleared at this port; also, the amount of revenue collected during the fiscal year ending June 30, 1874.

I am, very respectfully,

JNO. HITT,
Special Deputy Collector.

Maj. D. C. HOUSTON,
Brevet Col. U. S. Engineers.

Statement of the amount of revenue collected at the port of Chicago during the fiscal year ending June 30, 1874.

Duties.....	\$1,353,441 25
Tonnage.....	9,599 25
Hospital-money.....	8,214 56
Steamboat inspection.....	6,640 97
Total	1,377,896 03

Statement of vessels clearing to foreign ports from the port of Chicago during the fiscal year ending June 30, 1874.

Month.	Number of vessels.	Tonnage.	Number of crew.
1873.			
July.....	57	15,891	656
August.....	101	29,182	1,059
September.....	67	18,953	770
October.....	88	25,921	994
November.....	23	7,481	288
December.....			
1874.			
January.....			
February.....			
March.....			
April.....	20	5,675	171
May.....	54	16,658	610
June.....	66	19,754	704
Total.....	476	139,515	5,252

Statement of the number of vessels arrived from foreign ports to the port of Chicago during the fiscal year ending June 30, 1874.

Month.	Number of vessels.	Tonnage.	Number of crew.
1873.			
July.....	26	6,905	410
August.....	25	6,909	425
September.....	42	12,000	585
October.....	47	14,056	606
November.....	12	3,321	172
December.....	1	356	19
1874.			
January.....			
February.....			
March.....			
April.....			
May.....	35	10,823	376
June.....	24	6,930	365
Total.....	212	61,300	2,958

Statement of the number of vessels arriving coastwise to the port of Chicago, during the fiscal year ending June 30, 1874.

Month.	Number of vessels.	Tonnage.	Number of crew.
1873.			
July	1, 813	482, 361	16, 260
August	1, 793	486, 270	15, 921
September	1, 840	505, 286	16, 576
October	1, 412	413, 451	13, 182
November	746	261, 185	7, 579
December	37	18, 371	550
1874.			
January	5	2, 495	115
February	5	2, 501	115
March	43	9, 130	433
April	681	119, 420	5, 188
May	1, 551	437, 340	13, 614
June	1, 706	493, 983	15, 386
Total	11, 632	3, 231, 793	104, 919

Statement of the number of vessels clearing coastwise from the port of Chicago, during the fiscal year ending June 30, 1874.

Month.	Number of vessels.	Tonnage.	Number of crew.
1873.			
July	1, 779	480, 535	15, 956
August	1, 723	468, 718	15, 497
September	1, 694	458, 998	15, 125
October	1, 362	417, 161	13, 052
November	574	215, 187	6, 158
December	15	5, 726	246
1874.			
January	5	2, 405	115
February	6	2, 607	122
March	96	26, 742	787
April	898	180, 513	6, 888
May	1, 542	433, 548	13, 768
June	1, 611	460, 062	14, 591
Total	11, 305	3, 142, 292	102, 305

Financial statement.

Balance in Treasury of United States July 1, 1873	\$90, 000 00
Amount in hands of officer and subject to his check, (including \$6,866.32 percentage due on contracts not yet completed)	20, 423 47
Amount appropriated by act approved June 23, 1874	75, 000 00
Amount expended during the fiscal year ending June 30, 1874	107, 198 23
Amount available July 1, 1874	78, 225 24
Amount required for the fiscal year ending June 30, 1876	78, 000 00

B 14.

IMPROVEMENT OF CALUMET HARBOR, ILLINOIS.

The operations at this harbor are reported as follows by the assistant in immediate charge, First Lieut. F. A. Hinman, Corps of Engineers:

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., May 14, 1874.

SIR: The work at Calumet Harbor for that portion of the fiscal year ending June 30, 1874, during which I was in immediate charge, i. e., from June 30, 1873, to December 19, 1873, was as follows:

The north and south piers were each extended 200 feet, excepting the superstructure. The dimensions of the cribs of the former pier were 50 by 20 by 14½ feet, those of the latter pier being 50 by 20 by 10½ feet. The total extension of both piers, excepting the superstructure, during the working season of 1873 was 750 feet.

A number of the spaces between the ends of cribs were filled with brush and stone, the brush being obtained for the cutting of it.

The superstructure over the cribs sunk in extension of the north pier in 1872 was commenced and virtually completed.

Thirty-seven thousand four hundred and sixty-five cubic yards of material were excavated from the channel and crib-beds and dumped into the lake.

The soundings taken just before the close of operations for the season showed an improved channel of 11 feet, due to dredging.

The above work was done by hired labor, the materials being furnished by contract.

A light-keeper has been appointed, and a light is now regularly shown at the harbor during the season of navigation. It is understood that during the present season certain parties contemplate replacing the rope ferry over the river just above the entrance to the harbor, with a draw-bridge; also that the Lake Shore and Michigan Southern, and Pittsburgh, Fort Wayne, and Chicago Railroad Companies intend to rebuild their bridges over the Calumet River, putting in wider draws.

Respectfully submitted.

F. A. HINMAN,
First Lieutenant of Engineers, U. S. A.

Maj. D. C. HOUSTON,
Corps of Engineers, U. S. A.

I was relieved from the charge of this harbor by paragraph 2, Special Orders No. 140, War Department, Adjutant-General's Office, dated Washington, June 26, 1874.

The above report comprises all the work done during the year. The original estimate for this harbor was \$300,000 in round numbers.

(See Report of Chief of Engineers for 1871, page 104.)

There was appropriated in 1870	\$50,000
There was appropriated in 1871	50,000
There was appropriated in 1872	40,000
There was appropriated in 1873	40,000
There was appropriated in 1874	25,000
	205,000

It is considered that the cost of the harbor as originally designed will not exceed the estimate. The sum of \$75,000 can be profitably expended during the present fiscal year ending June 30, 1876.

The number of arrivals of vessels of all kinds at this harbor during the past year was 137, with a tonnage of 16,129 tons. Departures the same.

Financial statement.

Balance in Treasury of United States July 1, 1873	\$20,000 00
Amount in hands of officer and subject to his check	19,992 27
Amount appropriated by act approved June 23, 1874	25,000 00
Amount expended during the fiscal year ending June 30, 1874	39,273 05
Amount available July 1, 1874	25,719 22
Amount required for the fiscal year ending June 30, 1876	75,000 00

B 15.

IMPROVEMENT OF MICHIGAN CITY HARBOR, INDIANA.

The operations of this harbor are reported as follows by the assistant in immediate charge, First Lieut. F. A. Hinman, Corps of Engineers:

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., May 16, 1874.

SIR: I respectfully submit the following statement of work done at Michigan City Harbor during that portion of the fiscal year ending June 30, 1874, of which I was in immediate charge:

For the east pier of the outer harbor 240 piles were delivered and driven; 10,920 lineal feet of 12 by 12 inch pine timber were delivered and framed for superstructure; 13,632 feet, board-measure, 3-inch pine plank were delivered and laid for decking; the necessary stone and brush-filling and enough bolts and spikes were furnished to complete the same, according to the plan, for a distance of 503 feet from the end of the bridge. The above work was done by Messrs. Fox and Howard, of Chicago, Ill., under contract of date August 9, 1872. This contract has been closed.

The extension of the pier west of the entrance to the harbor was commenced last June by Mr. James H. Ledlie, of Chicago, Ill., under contract dated June 15, 1873. The work was completed before the expiration of the contract, December 1, 1873, and the contract closed. In the prosecution of this work 1,738 piles were delivered and driven; 13,706 lineal feet 12 by 12 inch pine timber were delivered and framed for superstructure; 14,304 feet, board-measure, 3-inch pine plank were delivered and laid for decking; the necessary brush and stone was put in for filling, and the amount of bolts and spikes needed was furnished.

The exposed portion of this pier was quite heavily ripped with stone. It is recommended that a permanent beacon be placed on the end of it. As it was thought that the brush and stone below the superstructure would settle considerably into the sand during the severe gales, the lower cross-timbers of the superstructure were occasionally omitted in both of the above-mentioned piers in order to allow stone from above to fall below and fill up the vacant spaces. The consequence was that the superstructure had to be filled with stone several times. It is likely that they will require refilling this spring.

The crib at the end of the pier east of the entrance to the harbor was repaired, as contemplated in my last annual report.

The above-named piers were located by me last November, and a map of the same submitted to you.

To complete the outer harbor according to the plan will require the construction of a breakwater and a short extension of the east pier. For a distance of 250 feet from the shore line this harbor is quite shallow, there being about 3 feet of water. Last fall the steam barge Eureka, loaded with stone, was wrecked in a gale between the two piers. She lay a total wreck about 300 feet east of the beacon pier.

No dredging has been done since June, but it may become necessary to do a little, as the soundings at the close of the operations for last season showed a scant 12-foot channel opposite the iron-ore dock. The docks belonging to private parties should be repaired in some places.

As directed by you, the foreman of each of my harbors have forwarded through me monthly progress sketches, showing the work done during the month; in case of pier-work, there was forwarded a tracing of an outline-plan and elevation of each pier, commencing at the shore-line on a scale of 1 inch to 100 feet, showing (in red ink) the plan and the elevation of the work done during the month; in case of pile-piers, there was furnished, in addition to the above, a plan and elevation of the work done during the month on a scale of 1 inch to 10 feet, on which was shown in plan each pile driven, and in elevation the condition of the work; in case of dredging, the cut was located on a map of the harbor and a tracing of the same forwarded to you.

Respectfully submitted.

F. A. HINMAN,
First Lieut. of Engineers, U. S. A.

I was relieved from the charge of this harbor by paragraph 2, Special Order No. 140, War Department, Adjutant-General's Office, dated Washington, June 26, 1874.

The only work done since the above report was a small amount of dredging between the old harbor piers during the spring of 1874. The

original estimate for this harbor (see Report of the Chief of Engineers for 1870, page 126) was \$324,421.40.

There has been appropriated in 1872.....	\$50,000
There has been appropriated in 1873.....	50,000
There has been appropriated in 1874.....	50,000
	150,000

It is estimated that the work can be completed within the estimate.

The estimate for the fiscal year ending June 30, 1876, is \$80,000.

The following is a list of marine arrivals and imports at this harbor for the year :

Arrivals	430
Lumber, feet, board-measure	36,500,000
Shingles	45,300,000
Laths	37,500,000
Iron-ore, tons	6,200
Pig-iron, tons	307
Coal, tons	600

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$50,000 00
Amount in hands of officer and subject to his check, (including \$1,499.41 percentage due on contracts not yet completed)	30,294 94
Amount appropriated by act approved June 23, 1874.....	50,000 00
Amount expended during the fiscal year ending June 30, 1874.....	78,241 93
Amount available July 1, 1874	52,053 01
Amount required for the fiscal year ending June 30, 1876	80,000 00

B 16.

IMPROVEMENT OF THE FOX AND WISCONSIN RIVERS.

The improvement of these rivers has been prosecuted during the year in accordance with the general plan submitted in my last annual report. The accompanying reports of the assistants in immediate charge show the work done in detail. It is proposed to continue this general plan this season, completing the work of last season on the Lower Fox and commencing the work on the Upper Fox.

The work on the Upper Fox will be on the new lock near Eureka ; dredging the bars from Berlin and below ; repairs and alterations of locks at Fort Winnebago and Governor's Bend, and deepening the canal at Portage City.

The work on the Wisconsin will be continued on the plan heretofore pursued.

A survey is now in progress to carry out the requirements of the harbor and river appropriation bill of June 23, 1874, in regard to the "northern route," recommended by the Senate Select Committee on Transportation Routes to the Seaboard.

Owing to the late date of the appropriation of this year a large portion of the working-season has been lost.

The estimate made by me last year for completing this improvement according to the plan adopted was \$3,000,000, since which time \$300,000 has been appropriated. A revised estimate and report based on the survey above mentioned will be submitted in time for action at the next session of Congress.

The estimated amount which could be profitably expended during the year ending June 30, 1876, is \$750,000.

The amount of tolls collected during the year ending June 30, 1874,

is \$1,239.17, required to be reported annually by act of Congress approved July 7, 1870. This is no criterion of the amount of business which might be done on the route, as it was closed during most of the year and the tolls are derived from local business.

The plan which has been adopted has been subjected to much criticism from parties interested in the route.

On the 24th of June, 1874, a convention was held at Oshkosh, Wis., composed of delegates from the various cities and towns on the route, at which the following resolutions were adopted :

Resolved, That we regard the improvement of the Fox and Wisconsin Rivers as an inter-State highway to be a work of very great and increasing importance; that the interests of the Northwestern States demand the construction of the work in accordance with the highest scale of measurements approved by General Houston in his report of June 30, 1873, and that appropriations for carrying on the work should be made by Congress, that the entire work may be well and fully completed within three years.

Resolved, That a committee be appointed by the chair, whose duty it shall be to act as a committee to present the wishes of the people, from time to time, in all matters pertaining to the manner of completing the improvement, and whose further duty it shall be to press upon the attention of Congress the necessity and the importance of the work; to make such suggestions to the authorities, from time to time, as they may deem advisable and expedient; and that the chairman of the convention be designated the chairman of said committee.

From this it will be seen that the plan recommended by me in my last annual report was indorsed.

I can but repeat that the appropriations heretofore made are disproportionate to the magnitude of this work, and inadequate to its completion, either with economy or reasonable rapidity.

It will require, according to present estimates, ten years to complete the work at this rate of appropriation.

There was appropriated in 1873, \$300,000, and the same amount in 1874.

The papers accompanying this report are as follows :

No. 1. Letter of Capt. Lydecker, dated August 12, 1874, transmitting report of Assistant Engineer Edwards on Fox River improvements.

No. 2. Report of Assistant Engineer Edwards, dated August 10, 1874.

No. 3. Letter of Lieutenant Hinman, dated July 25, 1874, transmitting report of Assistant Engineer Nader on Wisconsin River improvement.

No. 4. Report of Assistant Engineer Nader, dated July 24, 1874.

No. 5. Report of Assistant Engineer Nader, dated December 15, 1873.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$200,000 00
Amount in hands of officer and subject to his check.....	27,837 13
Amount received from tolls for year ending June 30, 1873.....	1,893 27
Amount appropriated by act approved June 23, 1874.....	300,000 00
Amount expended during the fiscal year ending June 30, 1874.....	229,907 92
Amount available July 1, 1874.....	299,822 48
Amount required for the fiscal year ending June 30, 1876.....	750,000 00

FOX RIVER.

Letter of Capt. G. J. Lydecker, Corps of Engineers.

UNITED STATES ENGINEER OFFICE, FOX RIVER IMPROVEMENT,
Appleton, Wis., August 12, 1874.

SIR: I have just received the annual report of N. M. Edwards, assistant engineer on the Fox River improvement, for that portion of the fiscal year ending June 30, 1874, during which he was in charge of the work.

There remains but little for me to add on the operations of that year. Very little work was done from the time I assumed charge, owing to the appropriation having been so nearly exhausted that we could not venture upon operations on an extensive scale until the new appropriation was assured to us.

During the month of May the only permanent force at work on the Lower Fox was that engaged in stone-cutting at Kaukauna quarries, for the lower combined lock at Little Chute.

In June commenced a general repair of boats, dredges, scows, &c., preparatory to commencement of active operations for this year. Temporary dams, which had been constructed last fall at Little Chute and the Cedars, were graveled and tightened up. Slight repairs were also made to the canal-banks at various points between De Pere and Kaukauna, where leaks appeared, threatening serious damage unless immediately attended to.

On the Upper Fox River no works of construction or repairs were in progress. On the 20th of May a small surveying party under N. E. Russell, assistant engineer, resumed work near Eureka, and continued the survey, which had been commenced last fall, up as far as Berlin. This was completed during the early part of June, after which the force was reduced to a leveling party of three men, charged with running a line of levels from the Wolf River up as far as Princeton.

For the fiscal year ending June 30, 1875, the amount allotted from the appropriation for the Fox and Wisconsin Rivers for use on the Fox River is \$200,000.

The plan of operations under which we are now working will expend this sum as follows:

Lower Fox River.....	\$75,000 00
Upper Fox River, including survey.....	110,000 00
Office, superintendence, and contingencies.....	15,000 00
Total	200,000 00

The principal works to be accomplished under the above plan are the completed construction of the new stone lock at Little Chute, and stone dam at Appleton, building a new dam at Kaukauna, and such repairs to locks, dams, &c., as may be required on the Lower Fox.

The construction of new lock and canal near Eureka, and possibly part of dam; the thorough repair of Winnebago lock, and to put the Portage Canal in good order for a depth of 5 feet and a width of 75 feet at low water, are the principal works contemplated on the Upper Fox during the present year.

Our two dredges will be constantly employed, one on the lower the other on the upper river. It is expected to obtain a complete and detailed survey of the Upper Fox River during this year. We will then be able to decide definitely upon the works required for its improvement.

My time has been so fully occupied since assuming charge here, that I have had little chance to study the works required for the complete improvement beyond those already in process of construction or repairs, and I shall not venture, therefore, to suggest what new works will be required until the survey of the upper river now in progress is completed. There is no doubt, however, that the proper prosecution of the work requires a large appropriation—much larger than heretofore.

Working under these small sums requires more or less suspension of navigation every year, which, under the present system, will be continued for several years to come, creating thereby much dissatisfaction all along the route. Besides, much of the money, in small sums, is necessarily frittered away in temporary repairs, which, with larger appropriations, could be increased and applied to permanent work.

To carry on this improvement in a satisfactory and economical way an appropriation of at least \$500,000 is needed for the fiscal year ending June 30, 1876.

In the transfer of the work from the old Canal Company, their rights and franchises with reference to the water-power were retained; and, as you have before reported, we have here a source of conflict with the best interests of navigation, and one which will seriously interfere with the work of improvement, unless Congress, by the necessary legislation, vests in the United States engineer in charge, or some other Government officer, the sole right to control the use of water by these water-powers.

Very respectfully, your obedient servant,

G. J. LYDECKER,
Captain of Engineers.

Maj. D. C. HOUSTON,
Corps of Engineers, U. S. A.

Report of Mr. N. M. Edwards, Assistant Engineer.

APPLETON, WIS., August 10, 1874.

SIR: I would respectfully present the following report upon the progress of work on the Fox River improvement from July 1, 1873, to April 30, 1874:

There being no authority from Congress for the purchase of lands for cut-offs or loca-

tion of locks, and the amount of money appropriated being limited, I was ordered to confine my estimates mainly to the Lower Fox River.

With the exception of an accurate survey of the locality of the proposed lock near Eureka by Mr. Russell, assistant engineer, and slight repairs to the works at Montello and Gov. Bend, no work was done on the Upper Fox River; that is, the river from Portage City to Lake Winnebago. Upon the Lower Fox, beginning at De Pere and passing up the river, only very slight repairs were made upon locks until reaching that at Rapid Croche. This stone lock was pumped out and repaired as follows:

A large quantity of gravel and clay was excavated, the floor partially relaid, and a sill, well secured by sheet-piling, was replaced from wall to wall below lower gates, for the purpose of putting in at any time, expeditiously and economically, a temporary dam. On account of relying upon a sill of this kind not sheet-piled, we were unsuccessful in pumping out this lock three months earlier. The lower miter-sill, which had raised, was well secured, and the masonry, lift-wall, and the gates repaired. The Rapid Croche dam was graveled and a few broken spars replaced, and flush-boards put on to keep up level so as to affect depth of water at the Kaukauna quarry landing.

Dredge No. 2 worked about three weeks in dredging clay, broken stone, and bowlders from the channel, within half a mile below the Rapid Croche lock.

Passing up to Kaukauna, a tool-house, 20 by 40 feet, was built at the second lock. The work of quarrying upon the islands was given up, as the Grignon quarry had been pumped out ready for working. This latter quarry, by reason of a more convenient access to a boat-landing, will be more available to our work.

A wooden track, which, in connection with an elevated track, car, and windlass, make expeditious and economical arrangements for loading boat with large blocks of stone.

At this quarry fine layers of blue limestone, very solid and strong, 12 to 30 inches thick, and free from seams, in places for 100 feet, were found. The balance of the stone from the lower combined lock was quarried during the fall, and the stone was cut for the lock during the year. The coping-stone for this lock is yet to be quarried and cut. Nearly 1,900 cubic yards of stone were quarried, the larger proportion of which is in blocks.

There were slight repairs made about the upper works of the locks, gates, capstans, &c. At Kaukauna the dam was graveled and slightly repaired. This dam is the poorest on the river, and hardly fit to expend money upon it for repairs. There is solid rock for a foundation, and a dam can be placed below the present one, requiring a height of dam of 12 to 13 feet. The length of this dam should be about 600 feet.

The fourth lock at Little Chute (the lower of the combined) was torn out at quite a large expense, the necessary excavation made, dam and pumping arrangements put in, together with an elevated traveling engine for unloading boats and replacing the stone in the wall of the lock. They were in working order late in the fall, and the south wall of the lock started, about 100 cubic yards of masonry being laid. Masonry work ended November 15.

The traveling engine on an elevated track 26 feet high and 30 feet gauge, by its steam-power hoists the stone from the boats below the dam, runs up the track, and, moving sideways, can lay in the wall, at any height or position, a block of five or six tons. This machine which you brought to my notice, and which by your directions was tried, works very successfully, and is the most expeditious way of handling heavy stone and laying cut-stone masonry I have ever seen used.

The stone for face of this lock has been taken out of quarry and cut for alternate courses of 2 and 3 feet depth and of from 4 to 7 feet in length and from 11 to 19 inches thick. The lock is to be in clear 160 feet by 35 feet, and to have a lift of 12 feet. The miter-sill to be at least 7 feet below top of Kaukauna dam or low-water level.

The waste-weir was constructed at Little Chute, third level, containing 160 cubic yards of masonry, built upon rock-bed 12 feet high. This has a water-way of 60 feet at the canal water-level, and a sluice-way 4 feet wide, extending below bottom of canal to the rock. Equal parts in paste of fat lime and Akron cement were used in the mortar.

A culvert of masonry was also constructed through the bank of second level Little Chute, with bottom below bottom of canal, 3½ feet square opening and 58 feet long. Four hundred and fifty yards of rock excavated from bottom of canal in the same level, within 150 feet of first lock.

A small amount of repairs and graveling was done on Little Chute dam. Upon the first and second locks at this point there was considerable carpenter-work expended in repairs of wood-work above water-line. At upper end of Little Chute level along the canal just below Cedars Lock, the banks were raised with earth-filling to the extent of 1,200 yards, and temporary dams put in, and water pumped out of about 700 feet of canal and the lock. There was excavated, before closing the work for winter, 600 cubic yards of gravel and 100 cubic yards of rock.

From De Pere to and including the Cedars lock and dam, Mr. Leonard Martin, assistant engineer, has charge; thence to mouth of Wolf River, Mr. W. J. Bryson, assistant engineer, has charge; thence to canal, at Portage City, is the section assigned to N. E. Russell, assistant engineer.

At the head of the Cedars level, extending from the fourth lock, at Appleton, for about 2,000 feet below, the channel has been in past time shallow, and the hardpan bottom in places being so hard that it was thought necessary to inclose and pump it out; but this has been avoided by removing the dipper from the handle-beam of the dredge, and replacing with a very heavy steel-pointed iron prong, with which the bottom was plowed to 2 feet in depth before excavating by the dipper. At this point dredge No. 2 excavated, over a length of 1,500 feet and an average width of 70 feet, 6,500 cubic yards of hard material during the latter part of the season.

The fourth lock was inclosed by temporary dam, and the lower section replanked and thoroughly put in repair below water-level.

The first lock at Appleton was pumped out, and during the fall the work below water-line was put in complete repair. The lift-wall and upper-wing wall, containing about 110 cubic yards, were relaid with face-joints in cut-stone masonry in a suitable manner, to incorporate in a new cut-stone lock, and may be put under the head of construction. The lower right-wing wall was laid in dry wall, and a slope-wall of about 60 feet in length was laid below the lower right wing.

The long pier extending above the first lock to the dam, 800 feet long, and from 14 to 22 feet high, was retimbered above low-water mark on the basin side; also double-planked to the rock-bottom. This planking of two courses, planed and tightly-jointed, was scribed to the rock and banked with gravel to a depth of 3 to 6 feet. I see no reason why the face of this planking and crib-work below water should not last and be practically tight for twenty years or more.

The lower, or river-face of this pier, after removing the timber, I would advise, should be faced with a dry wall of heavy stone; the stone can be excavated in river near foot of pier.

The upper dam at Appleton was partially removed in September of last year, and the new dam begun. Masonry-work on this dam was closed for the season November 22, 1873, 315 feet in length being entirely completed, and 23 feet partially. The dam is laid upon a heavy course of very hard limestone-rock in its natural bed. Both the upper and lower faces were laid in courses of cut-stone taken from the river-bed at this point. The lower course on lower face was doweled to rock, the top consisting of heavy block only, being brought from quarry at Kaukauna. These coping-stones were 4 feet square, 13 to 19 inches thick, thoroughly clamped together. The abutment at the south end of dam, 25 feet in length, was nearly completed, being laid in courses, and carried up a little higher than dam. The masonry in dam and abutment contains 975 cubic yards. About 73 cubic yards of face-stone for finishing the dam were cut during the winter months, having been quarried during the fall.

A temporary dam, in from 8 to 10 feet of water, 450 feet in length, was thrown across from the old dam near its center to the south bank of river, to allow the construction of the south half of the stone dam to repair the first lock, and reface the long pier.

It was constructed of 16 cribs, so made as to receive horizontal stringers from 24 to 28 feet long, one set two feet from bottom and another at water-surface, placed to receive 3-inch plank at angles of 50° with horizon. This dam enabled us to work a good quarry of stone in the bed of the river-basin above the stone dam, from which were taken 650 cubic yards of stone for cutting, and 950 cubic yards of rubble. There is on hand, quarried as this point, for finishing dam, nearly enough coping-stone from Kaukauna—73 cubic yards of stone cut for face, and 900 cubic yards of rubble.

In the river, three-fourths of a mile above the upper dam at Appleton, through what was known as the "Appleton Rapids," dredge No. 1, assisted by the United States steamer Crawford dredged a channel from 60 to 80 feet wide, leaving a depth of from 5 to 7 feet at low water. An estimate gives from 2,000 to 2,200 cubic yards, and from 40 to 50 cords of bowlders having been removed. The material was clay, gravel, and bowlders, requiring to be plowed; this was done in the latter part of September and during October and part of November.

In August, the same dredge excavated from Menasha lock 940 feet into Little Lake Buttes des Morts, 60 feet wide, and to a depth averaging 5 feet at low water. This required 1½ feet depth of excavation, 2,800 to 3,000 yards being excavated, the material being gravel and clay. At the outlet of Lake Winnebago, Menasha Channel, this dredge worked during July and a few days in August, increasing the width of 6-foot channel to about 60 feet. The material has been deposited on the shore side, and I would recommend the excavation and removal by dump-scows so as to give a channel of at least 150 feet in width.

The accompanying statement will show the expenditures for labor, and bills which have passed through this office, from July 1, 1873, to April 30, 1874.

Statement of expenditures from July 1, 1873, to April 30, 1874.

Repairs	\$17,468 58
Construction	75,363 38
Cost of boats, tools, tool-house, and machinery.....	14,722 82

Outfit, additions, repairs, and fuel of dredges, boats, and scows.....	\$6,920 85
Surveys.....	1,827 86
Engineering.....	7,000 00
Operating canal.....	2,240 40
Office.....	1,877 12
Total	127,421 01

An accurate survey was made by Mr. Russell of the North or Menasha Channel, together with the soundings for a width of one-half to two-thirds of a mile along over three miles of the north shore of Lake Winnebago. Examinations and surveys were made some miles east and west of the two outlets of this lake for better canal outlet, and no route, so far as economy is concerned, can be constructed to compare with either of these channels.

So far as water-powers are concerned, I do not think that the use of what water will probably be available on the North Channel, with proper restrictions as to the amount of water used to the cross-section of canal, will materially obstruct navigation.

They are all secondary to the interests of navigation, and the rights of the Government to prohibit the use of the water after being drawn down to a certain point, to the top of all new dams, or a datum at the locks, for instance, (the Government works not unnecessarily wasting water,) would seem to be clear.

Of the two channels or outlets of the lake, the North or Menasha Channel offers the least difficulties, and is the more economical to improve to a depth of 6 feet. At the outlet into the lake at this channel there is over 6 feet over the rock in place at low water, and the rock met with below can be readily and cheaply excavated by closing the channel by a dam, as has been done before. The Government should, in my opinion, fix and regulate the standard of heights of water in the various lakes, and a law be passed to effect that object. The questions of land-flowage and water-powers are getting to be of greater and greater magnitude, and some definite standard now will obviate many difficulties in the future.

By a greater width, or (what might accomplish the object) depth of discharge during the rainy season, thus preventing the extreme high water, and arranged so that by closing part or the whole of the discharge, the water can be kept back to level above, former low-water mark.

This will obviate much injury to lands overflowed in the months of May and June, and give greater depth for navigation in dry seasons, without further injury to lands.

By your instructions of May 8, 1874, Capt. G. J. Lydecker, Corps of Engineers, U. S. A. assumed charge of the works May 12, and, by your orders, I reported to him as assistant.

Very respectfully, your obedient servant,

N. M. EDWARDS,
Assistant Engineer.

Maj. D. C. HOUSTON,
Corps of Engineers, U. S. A.
Through Capt. G. J. LYDECKER.

WISCONSIN RIVER.

Letter of Lieut. F. A. Hinman, Corps of Engineers.

UNITED STATES ENGINEER OFFICE,
Madison, Wis., July 25, 1874.

SIR: I have the honor to transmit herewith Assistant Engineer John Nader's report of operations on the Wisconsin River improvement, for the fiscal year ending June 30, 1874.

In approving of the aforesaid report, I would state that I favor Assistant Nader's first project for the future conduct of the improvement, for the reasons set forth by him.

Maps of surveys of the bridge sites, referred to in his report, will be forwarded to you as soon as completed; also plans of changes in the bridges that may become necessary.

A plan and estimates of a dredge and snag boat will also be submitted. It is proposed to build this boat by contract, as suggested by you.

As I have but very recently assumed charge of this improvement, I have not yet had an opportunity to inspect it, and would therefore respectfully refer you in connection with this to my detailed report (dated September 18, 1873) of an inspection made by me that covered the whole of the river then improved.

Very respectfully, your obedient servant,

F. A. HINMAN,
First Lieut. of Engineers, U. S. A.

Maj. D. C. HOUSTON,
Corps of Engineers, U. S. A.

Report of Mr. John Nader, Assistant Engineer.

MADISON, WIS., July 24, 1874.

SIR: The operations were continued at the commencement of the fiscal year according to the plan adopted and prosecuted during the two previous years, i. e., the improvement of the river proper by means of wing-dams constructed of brush and stone.

The cost and amount of work done appears in my report of operations for the season ending December 31, 1873, to which report I would most respectfully refer you. Since that time there has been no work done, the work being practically closed on October 15, 1873, for want of funds; and no appropriation being made so as to be available before the end of the fiscal year, the works necessarily remained in the same condition as at the end of the season of 1873.

It was hoped to increase the thirty-nine miles of improved river to at least fifty miles, but the foregoing remarks will explain why the same was not done.

Annexed is a detailed monthly statement of expenditures during the fiscal year.

REPORT OF THE CHIEF OF ENGINEERS.

Detailed monthly statement of expenditures for twelve months ending June 30, 1874.

Class of expenditure.	1873.						1874.						Total.
	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	
Engineers and superintendents.....	\$1,139 00	\$1,054 50	\$1,035 00	\$1,054 50	\$450 00	\$450 00	\$300 00	\$300 00	\$300 00	\$300 00	\$300 00	\$300 00	\$6,976 00
Boat-hire.....	1,170 00	1,170 00	1,170 00	585 00	.....	.....	.....	.....	.....	.....	.....	.....	4,085 00
Fuel for boats.....	502 18	503 50	411 19	990 63	.....	.....	.....	.....	.....	.....	.....	.....	1,707 49
Crews of boats.....	655 66	673 00	700 00	691 00	.....	.....	.....	.....	.....	50 41	9 99	.....	2,790 06
Subsistence of crew.....	906 19	924 19	930 85	839 40	.....	.....	.....	.....	.....	14 00	.....	.....	2,907 58
Labor.....	4,531 66	4,619 37	4,531 83	2,944 16	260 00	529 00	929 00	927 00	939 00	948 50	939 00	935 00	18,546 59
Team-hire.....	4,697 09	900 87	198 51	100 12	7 00	.....	.....	.....	.....	.....	.....	.....	1,932 53
Materials.....	4,035 08	3,326 44	4,478 55	2,616 34	.....	.....	.....	.....	.....	11 52	.....	.....	14,477 93
Contingencies.....	31 25	45 10	127 10	99 90	37 50	.....	.....	.....	38 76	34 10	17 10	59 55	490 42
Total.....	12,891 04	11,819 90	12,893 02	9,704 13	754 50	639 00	539 00	537 00	577 76	658 53	566 09	594 35	51,904 52

Cost of work.

The cost of work, including equipment and repairs, has remained practically the same as for previous work.

From July 1 to November 1, 1873, the total expenditure, as will be seen from the foregoing detailed statement, was \$46,298.09. The work done in the mean time was twenty-three dams of a total length of 12,891 feet, whence the cost of dams equals a small fraction over \$3.59 per lineal foot; this, I believe, can now be reduced at least 10 per cent, as the parties are all well equipped, and both overseers and men have learned by experience to work at better advantage.

Condition and general results of the work.

The dams, with few exceptions, have stood well, both against high water and ice. In two cases they have gone out, the cause of which will be mentioned farther on.

When built in three or four feet of water the dams have remained just as they were built, except the sagging of the brush; wherever they were built in five feet or over, the sagging amounted to considerable, and always caused an overflow more or less extensive, requiring the raising of the dam.

In closing of lateral branches it often happened that the dam had to be built over a middle bar; in each case a settling would take place at the juncture of the bar and the deeper water; in a few cases this amounted to as much as 8 feet.

In the two cases where the dams went out as above mentioned, it happened that a dry bar was located in the line of the dam, and it was considered sufficient to excavate a trench, lay down the successive layers of brush, and load them with sand; the head of the dam was, like the other dams, built of brush and stone; the sand-loaded portion went out, but the head remains sound but isolated, forming an island.

A piece of bank-protection of 2,475 lineal feet was built at Portage City in July, 1873, at a total cost of \$1,285.30. The same was built as follows: The bank was first graded to a slope of 40° from the horizontal; from two to three rows of brush-mats (depending upon the depth) were laid along the slope from the bottom to about ordinary low water, and the whole covered with coarse gravel to the top of the bank, the gravel being less than 6 inches in depth. This protection, costing about 50 cents per lineal foot, has withstood high water, ice, and landing of rafts, is now in better condition than when completed, and at the same time clearly demonstrates the proper method of bank-protection, wherever the same may be necessary along the line of the improvement.

The general result of the work has been all that could be desired.

The condition of the river is not as good, as a general thing, at the present date as it was at the end of last season, owing to the slight spring rise, which was insufficient to deposit the sand in the eddies formed, simply moving the same a short distance, and in some cases leaving a flat bed with from 2½ to 3 feet of water. In every case where work has been done the effect is very apparent; the river has assumed more regularity in its course; the bars are rapidly disappearing, and a general deposit is slowly going on above and below the dams, so far as their influence extends. The changes have been very slow, owing to the failure of the usual freshets, which alone can clear the desired channel. From 1870 the only rise of importance was in June, 1873, amounting to from 5 to 6 feet; the remainder of the time water was so low as to make it difficult to get about, and the action of the dams was thereby much retarded.

The worst places operated upon give the best results, as they were necessarily more vigorously attacked.

Duck Creek Flats has now a defined channel never before known, but the same is yet incomplete, the dam forming the same having been the last of the season of 1873.

Merrimac Flats, never known to have more than 1.50 feet at low water before the improvement, has now a channel of full 5 feet.

Allen's Flat has gradually adjusted itself from above downward to not less than 4 feet of water, excepting the lower end, where the current has not had time to remove the sand, and there remains a bar with about 2 feet of water.

Muscoda Flat has a 4-foot channel, which is yet somewhat crooked, but gives every indication of a permanent channel.

For the greater part of the improved river there is a depth of from 4 to 7 feet, and this will easily be maintained if the water is forced to maintain a permanent location.

Projects of operations for the fiscal year ending June 30, 1875.

One of two projects may be adopted. The first is to progress as rapidly as possible without attempting to complete the improvement, but simply to close all lateral channels in order to get the river permanently into one channel, and also to construct occasional wing-dams where it is very wide; this would give the river an opportunity of adjusting its regimen more gradually, and to adopt the most natural course.

The second is to finish up the work as it progresses. This project would be more tedious than the first, and would probably require more dams than the first project would ultimately require.

By carrying out the first project the parties now at work would advance about thirty miles, with an expenditure of \$75,000, making the whole distance worked over sixty-nine miles.

With one additional party another five miles could be pretty thoroughly improved at an additional expense of \$15,000, making thirty-five miles at a cost of \$90,000.

By the second, the present working parties would make about twenty miles at the same cost, \$75,000; the work and expenditure for an additional party would be the same as in the first project, making twenty-five miles at same expenditure as above, \$90,000.

The first project would probably be the most desirable, as it would afterward greatly facilitate the moving of materials; the brush in the vicinity of the work would then be sufficient to do the required work, whereas now the same must sometimes be carried several miles after the islands and bottom-lands in the vicinity have been cut over; the second growth would furnish the necessary brush to complete the work.

Another advantage would be, that the raft-channel would be improved for a longer distance, which would be an advantage to the lumbering interests.

In this connection it would be advisable, if funds would permit, to do some preliminary work on the following plats: Honey Creek, Blue Mound Prairie, Helena Crossing, Brisbois Slough, and Jones Dale. If these places were improved only to two feet, it would be of great benefit to the Yellow River lumbering business. The lumber merchants of the Yellow River district already recognize the benefits derived from what has already been done on the river, and are thinking seriously of improving the worst places between Portage City and Yellow River, a distance of forty miles, at their own expense, and on the same plan adopted on the improvement, being confident of thereby being enabled to run out lumber on low water, when the up-river lumber is unable to pass the falls.

The obstruction rendered by the upper and middle railroad bridges must be removed next winter, as it is impossible to pass a boat through even at high water. The officers of the Milwaukee and St. Paul Railroad Company seem perfectly willing to make the change as soon as called upon, but expect to be excused until the change was a real necessity. This it now is, and they should at an early date be called upon to prepare for next winter.

The bridges are now composed of spans of 100 feet, and I understand their plan to be to take out two spans and cover this interval by a swing-bridge, which will give about 80-feet openings on both sides of the center pier.

The benefits already derived from the improvement have been: That rafts, having once arrived at Portage City, have run over the improvement without hindrance or delay; the same also when they reached the lower work, from Richland City to Port Andrew; also, that the steamer Ellen Hardy has been carrying grain at an expense of 2 cents per bushel from Sauk City to Portage, until the depth of water below the improvement was insufficient to run the boat.

One very important fact in connection with the improvement is, that the work should be commenced as early as possible in the spring; the water is then at a fair stage, and laborers can be had in abundance; also, teams and materials.

The appropriations heretofore available have been entirely too small to prosecute the work to a degree compatible with the scheme.

The purchase of a dredge and snag boat is again earnestly recommended.

Respectfully submitted,

JOHN NADER,
Assistant Engineer.

Lieut. F. A. HINMAN,
Corps of Engineers, U. S. A.

Report of Mr. John Nader, Assistant Engineer.

MADISON, WIS., December 15, 1873.

SIR: The operations were resumed in April of the present season at the points left off in the previous year.

The upper party at Merrimac, and the lower party at Muscoda. A third party was organized and commenced operations at Portage City, on the unimproved five miles above the operations of 1871.

The following is the amount of work done during the season:

Portage party	14 dams, 4,649 linear feet-
Merrimac party	10 dams, 6,732 linear feet-
Muscoda party	14 dams, 6,996 linear feet-
Total	38 dams, 18,377 linear feet.

Bank-protection at Portage City.....	2,475
Scows built, 45 feet long.....	4
Steam-scows built.....	3

One of the latter was built to replace the hull of the old steam-scow; the old hull was applied to the United States quarter-boat, which had been used on the survey in 1867.

The steam-scows are flat-bottom boats, 75 feet long, 16½ feet beam, and 44 inches deep, with pointed bow, square stern, stern-wheel, and draw, light, 12 inches aft, and 3 inches forward.

Summary statement of work done to December 1, 1873:

Total number of dams built	94
Total number of linear feet.....	38,517
Total number of linear feet—bank-protection.....	2,475
Scows built, 70 feet long	4
Scows built, 45 feet long.....	6
Steam-scows built.....	4
Quarter-boat built.....	1
River-scrapers built	3
1 quarter-boat hull, replaced by hull of first steam scow.	•

The following will show the amount of rock and brush used in construction of dams per 100 feet length:

Length of dam.	Depth of water.	Rock.	Brush.
<i>Feet.</i>	<i>Feet.</i>	<i>Cords.</i>	<i>Cords.</i>
250	2. 50	8	25
195	2. 50	12	22
339	3. 50	10½	27.5
102	3. 50	10	27
300	4. 00	14	32
Maximum.....	.....	14	32
Minimum.....	.....	8	22
Average.....	.....	11	27

Fascines made per day per man	25
Mats made per day per man.....	20
Mats sunk per day per man.....	10

Three mats will average 1 cord of brush.

Cost of labor, material, boat-hire, &c., expended on the improvement of the Wisconsin River during the season of 1873.

Class of expenditure.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
Engineer and superintendents.....	\$443 00	\$434 00	\$443 00	\$879 00	\$1,116 50	\$1,128 50	\$1,132 00	\$1,054 50	\$1,035 00	\$1,054 50	\$450 00	\$450 00	\$9,614 00
Boat-hire.....	.....	.....	.....	.....	540 00	1,125 00	1,170 00	1,170 00	1,170 00	585 00	.....	.....	5,760 00
Fuel for boats.....	.....	.....	.....	85 00	302 34	349 87	503 18	503 50	411 13	290 62	.....	.....	2,454 63
Crews of boats.....	.....	.....	26 00	317 99	590 99	665 00	655 66	673 00	700 00	691 00	.....	.....	4,319 64
Subsistence of crews.....	.....	.....	.....	53 50	150 17	189 90	206 13	224 13	230 85	223 49	.....	.....	1,392 15
Labor.....	266 00	248 00	305 50	1,650 69	3,869 03	4,094 24	4,531 66	4,613 37	4,531 83	2,944 16	260 00	239 00	27,552 43
Team-hire.....	.....	.....	.....	1,104 85	56 66	94 58	4,637 09	200 87	198 51	190 12	7 00	.....	1,479 68
Materials.....	54 80	.....	376 73	2,337 98	4,487 23	4,068 65	4,035 08	3,336 44	4,478 55	2,616 34	.....	.....	25,726 39
Contingencies.....	.....	18 80	82 60	79 43	87 90	194 17	31 25	45 10	127 16	99 90	37 50	.....	788 80
Total.....	763 80	700 80	1,223 22	5,513 43	11,290 83	11,833 31	12,201 04	11,819 90	12,883 02	8,704 13	754 50	689 00	73,987 57

The appended sketch A shows the progress of the improvements. The dark portions represent that portion of the river which is practically completed, and needs but little additional work; the shaded portions represent the work contemplated to July 1, 1874.

Sketch B shows the work done at Portage City, giving location of dams, their length, and date of building.

Sketch C shows the work of the Merrimac party.

Sketch D shows the work of the Muscoda party.

The Portage party has worked over a space of three and one-half miles during the season with great success; the steamer Granite State, which was engaged on this section, ran over the whole distance in October, the water being at one foot above lowest known, and the boat drawing over three feet.

The Merrimac party has worked over a space of four and one-half miles with equal success, forming a 3-foot channel as rapidly as the work progressed. This party had the task of improving Merrimac Flats, which previously never had over 1.5 feet at low water, whereas, now, an apparently permanent channel of $3\frac{1}{4}$ feet exists over the flats.

The Muscoda party has worked from Muscoda downward, a distance of seven miles, completing the season's work by closing Tiger Slough, and returning to Muscoda on October 16, for winter quarters. The Winneconne, drawing 34 inches, made the trip back over the work of the season, with scows and quarter-boat in tow without any difficulty.

The work, thus far, extends over a space of thirty-nine miles, or nearly one-third of the river, which will require very little more work to perfect the same. There will be required two dams in the vicinity of Dekorra, seven miles below Portage City, and the raising of several of the dams of 1871. Several of the dams on Allen's Flats, nine miles below Portage, require lengthening; at the lower end of these flats there was an accumulation of sand which turned the channel into a side branch of the river, which, under the circumstances, it will be advisable to preserve, unless the channel originally designed will be found clear, after the opening of next season. About 900 feet of dam will secure the desired effect. A settling of No. 8 of 1872, 100 feet long, leaves a doubtful channel for about one-half mile; the repairs of this dam will secure over 4 feet over this space. Between here and the end of this season's work (seven miles) very little improvement will be necessary; three dams and some bank-protection will probably complete the channel.

From Richland City to Port Andrew, a distance of thirteen miles, the channel is over 3 feet and improving, with the exception of three bars, which will require four dams to correct the same.

Borings were made at Orion and Port Andrew to bed-rock, which was found to be not less than 6 feet below low water; it was hence determined to turn the channel in both cases into the north branch of the river, thereby securing one substantial rock-bank, and giving the towns the benefit of the improvement. At Port Andrew this was done in October by closing Little and Big Tiger Sloughs; at Orion this can only be done at a fair stage of water when rafts prefer Orion Slough, and will be less likely to interfere with the operations. The work mentioned will probably be the first work of the Muscoda party next spring.

The amount of work probably completed by the end of the present fiscal year (June 30, 1874,) will be fifty miles.

In order to carry on the improvements as rapidly as desirable during the next season, an available appropriation of \$175,000 will be required. The purchase of a snag-boat is recommended to be operated next season. Accompanying this report is a diagram of water-gauges of 1873.

Respectfully submitted.

JOHN NADER,
Assistant Engineer.

Col. D. C. HOUSTON,
United States Corps of Engineers.

APPENDIX C.

ANNUAL REPORT OF CAPTAIN S. M. MANSFIELD, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1874.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., August 3, 1874.

GENERAL: I have the honor to forward herewith my annual reports relating to the works of harbor improvements under my charge for the fiscal year ending June 30, 1874.

Very respectfully, your obedient servant,

S. M. MANSFIELD,

Captain of Engineers and Bvt. Lieut. Col., U. S. A.

Brig. Gen. A. A. HUMPHREYS,

Chief of Engineers, U. S. A.

C I.

FRANKFORT HARBOR, MICHIGAN.

The original plan of improvement of this harbor embraced, as estimated,

400 feet sheet-piling	\$3,259 50
320 feet pier-work	13,191 60
800 feet pier-work	52,305 50
1,520 running feet	68,756 60
Dredging 64,080 cubic yards, at 25 cents per yard	22,743 10
Total	91,499 70

and contemplated a new cut and two parallel lines of pier-work, with a width of 200 feet between the cut through the strip of land which separated the river basin or pond from Lake Michigan; the length of north pier 720 feet, and of the south pier 800 feet. The new cut to be 750 south of old outlet.

From a resurvey (August, 1867,) a change in plan required an extension of the piers further into the lake, which increased the estimate for close-piling and dredging; the north pier to be 672 feet, (21 cribs,) south pier, 832 feet, (26 cribs;) 550 feet close-piling and 85,000 cubic yards dredging; estimated as follows:

For pier-work, 47 cribs	\$103,400
For close-piling, 550 feet	13,000
For dredging	30,000
Total	146,400

Appropriated 1866-'67

98,541

1867 and 1868. Work commenced July 1, 1867, and up to June 30, 1868, there was constructed 384 running feet of pier, (12 cribs;) 525 running feet of close-piling, and 117,573 cubic yards of sand, earth, and clay removed.

Allotted June 30, 1868

\$10,000

1868 and 1869. During this fiscal year 12,641 cubic yards of earth was removed from between the piers; 114 cords brush put in piers; 382 cords of stone placed, and 165 cubic feet timber furnished.

Allotted June 30, 1869

\$31,500

To make a good harbor of refuge, it was recommended that both piers be carried out to the 12-foot curve, 390 feet, and channel dredged to 14 feet; cost, \$60,000.

1869 and 1870.—During this year the north pier was extended 320 feet; channel dredged to 11 feet of water, and east end of channel-revetments protected by wings.

Transferred to Grand Haven.....	\$1,885
Appropriated July 11, 1870.....	10,000

Former recommendation, that the piers be extended 390 feet, renewed.

1870 and 1871.—The wings on east ends of north and south piers extended 210 feet; 1 crib (64 feet) sunk in extension of north pier, and channel dredged to 12 feet water.

Appropriated March 3, 1871.....	\$10,000 00
Less amount covered into Treasury, (act July 12, 1871)	5,721 50

4,278 50

Recommendation for extension of piers reiterated; the north pier 264 feet and south pier 328 feet. Also, that channel be dredged to 14 feet. Work to cost \$56,000.

1871 and 1872.—Two cribs, (64 feet,) one on each, were placed in extension of the piers and superstructure built over them; also over the crib sunk in 1871. The north pile-revetment was reballasted with stone. Appropriated June 10, 1872

\$10,000

A further addition of 264 feet to each pier was recommended, to cost the estimate of 1871, less \$10,000 appropriated, \$46,000.

1872 and 1873.—The south pier was extended 65 feet, (1 crib.)

Appropriation March 3, 1873.....	\$10,000
----------------------------------	----------

To dredge the channel, it was estimated that \$10,000 would be required, in addition to the \$36,000 for construction of the remaining 378 feet of piers, 214 on south and 164 on north side.

1873 and 1874.—Work accomplished in the year ending June 30, 1874: Three cribs were sunk in prolongation of south pier, extending it 150 feet, and superstructure placed over them, under contract of May 10, 1873, with William Nicolls.

Appropriated June 23, 1874.....	\$10,000
---------------------------------	----------

During this season it is intended to sink one crib (50 by 30 by 26½ feet) in extension of the south pier, to do necessary dredging in channel, and close intervals between cribs in the present work, through which a large quantity of sand finds its way into the channel, and make some necessary repairs to the filling.

The recommendations of last year are here renewed, as well as the estimate, less \$10,000 just appropriated.

From the above review, it appears that the original plan of improvement adopted (1866-'67) contemplated an expenditure of \$146,400, which, in June, 1869, was increased by an additional estimate of \$60,000.

There have been appropriated and allotted for this harbor the following sums:

In 1866-'67	\$98,541
In 1868	10,000
In 1869, \$31,500, less \$1,885 transferred to Grand Haven	29,615
In 1870	10,000
In 1871	10,000
In 1872	10,000
In 1873	10,000
In 1874	10,000

Total	188,156
-------------	---------

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$15,007 97
Deduct amount expended last fiscal year.....	441 46
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874	12,178 89
Amount available July 1, 1874	12,387 62
Amount required for the fiscal year ending June 30, 1876	36,000 00

Statement of vessels entered and cleared at Frankfort Harbor from July 1, 1873, to July 1, 1874.

	No.	Tonnage.	Crews.
Entered	321	53,349	3,190
Cleared.....	320	51,848	3,197

An increase of about 10,000 tons over last year.

C 2.

MANISTEE HARBOR, MICHIGAN.

1866.—The original estimate for the improvement of this harbor was \$180,949, to be expended in 960 lineal feet crib-work on each side of the channel, which would, at that time, carry the pier-ends into 12 feet water.

1866 and 1867.—In the spring of 1867, 24 cribs, equal to 768 lineal feet, were contracted for.

Allotted..... \$60,000

1867 and 1868.—During this fiscal year there were 448 lineal feet of pier-work built, and 18,326 cubic yards of earth and sand removed from channel. The pier-work was composed of 14 cribs, (32 feet long,) 4 on south and 10 on north pier. The superstructure over cribs in north pier was completed and filled with stone.

No appropriation given this year.

1868 and 1869.—During the year the south pier was extended 256 feet, and the north pier 96 feet. It was then suggested by Col. F. U. Farquhar that to complete the improvement of this harbor both piers should be extended, the north 512 feet and the south 608 feet, at a probable cost of \$70,000. He also recommended the removal of the angle on the south side of channel and the bank revetted; estimated cost, \$9,000.

No appropriation given this year.

1869 and 1870.—Some repairs were made on the north side of channel, at the inner end of north pier, where a breach appeared imminent. To guard against this the city authorities had some piles driven and furnished slabs, &c., the United States paying for labor. One crib (64 feet by 20 feet) was built, but not sunk.

Appropriated July 11, 1870.....\$20,000

1870 and 1871.—Each pier was extended 158 feet, (two cribs of 64 feet by 20 feet, and one of 30 feet square.)

Appropriated March 3, 1871..... \$9,000

The large fire, which consumed the greater part of the city, destroyed 10,755 cubic feet of pine timber, and some oak, belonging to the United States, as well as burned the superstructure of 115 feet of south pier.

After the fire, the contractor (Thurber) failed to go on with his contract, and in the following spring (1872) the work was finished by hired labor.

1871 and 1872.—The superstructure on the six cribs, sunk last season, was completed during this year, and the 115 feet of burned superstructure replaced, as well as 600 feet of revetment begun on the north side of the channel.

Appropriated June 10, 1872.....\$10,000

The citizens in the lumber interest purchased a dredge and scows, and succeeded in deepening the river between lake and lake. Their efforts will be futile unless the piers are carried out into deeper water; therefore an additional estimate was made, to carry pier-ends into 16 feet water, of \$112,000.

1872 and 1873.—The 600 feet of revetment on north side of channel was finished early in the season, and a contract let for dredging off the point or angle on south side of channel and revetting bank exposed. Part of this work was done, but being late in the season, and work having to be done in an exposed position, the work progressed very slowly, and was not completed by the time the contract expired.

Appropriated March 3, 1873.....\$10,000

1873 and 1874.—Three hundred and fifty feet of revetment was finished at the end of May, to which time above-mentioned contract was extended. The angle or point on the south side having been cut off, allows a heavy swell to drive against the river-bank just inside the end of the 600 feet of revetment on the north side, causing quite a wash of sand into the channel. To obviate this, 355 feet of revetment will have to be added to the revetment of 1872-73, terminating at a sandy point, but above where the sea from without or the current down the river will strike. It is proposed to do this work this season. It will require still 140 feet of revetment to completely protect the bank on south side where the point or angle was removed. This 495 feet of revetment, it is expected, will be finished this season.

To carry out the recommendation contained in my last report, viz, to carry the piers past all shoaler water into a depth of 16 feet, will require north and south extensions of 650 and 750 feet, respectively; 28 cribs, 50 feet long, which, at \$4,000 each, would cost \$112,000.

It appears that the original plan of improvement was estimated to cost \$180,974. There has been appropriated and allotted to this work:

In 1867.....	\$60,000
In 1870.....	20,000
In 1871.....	9,000
In 1872.....	10,000
In 1873.....	10,000
In 1874.....	10,000
Total	119,000

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$15,000 87
Deduct amount expended in last fiscal year.....	3,313 00
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	10,945 74
Amount available July 1, 1874.....	10,742 13
Amount required for the fiscal year ending June 30, 1876.....	50,000 00

Statement of vessels entered and cleared at Manistee Harbor, Michigan, from July 1, 1873, to July 1, 1874.

Entered: number, 1,705; tonnage, 337,000; men, 15,120.

Cleared: number, 1,755; tonnage, 339,720; men, 15,530.

An increase of about 75,000 tons over last year.

C 3.

LUDINGTON (PÈRE MARQUETTE) HARBOR, MICHIGAN.

There were two propositions for improving this harbor; one estimated to cost \$270,682.16, at the first or present entrance, the other, distant about a mile, to cost (new cut) \$269,136.49.

These amounts were very nearly equal, but it was thought the money could be expended to greater advantage at present entrance.

Appropriated 1867:..... \$50,000

1867 and 1868.—During the year 19 cribs were built and sunk, making 608 feet of pier, 17 cribs on the south and two on the north side. The piers were built to the surface of the water.

The plan adopted for the improvement here was, to build a south pier, commencing at a point 20 feet south of the slab-pier, extending into Lake Michigan 640 feet; to build a north pier, in extension of the present (1867) pier, 450 feet long; to remove old slab-pier on south side, and cut down slab-work on north side, replacing it by timber superstructure. The direction of piers to be 3° north of west, and the channel 200 feet wide.

1868 and 1869.—The superstructure was put on south pier, and four cribs (128 feet) added to the north pier, as well as 8,900 cubic yards of earth and sand removed from the channel.

Allotted..... \$31,500

1869 and 1870.—The north pier was extended 384 feet, (12 cribs;) a superstructure was put over cribs sunk in 1868.

"It is urgently recommended that the old slab-pier on south side be removed, and the bank revetted; estimated cost, \$52,000."

Appropriated July 11, 1870..... \$10,000

1870 and 1871.—The superstructure over the entire north pier was finished this year, and the piers thoroughly ballasted.

Appropriated March 3, 1871..... \$10,000

1871 and 1872.—A crib 30 feet square was placed at outer end of north pier, and 135 feet of pile-pier built east from south crib-pier; and dredging from the channel and the old slab-pier by United States machinery.

Appropriated June 10, 1872..... \$10,000

1872 and 1873.—Two hundred feet of south slab-pier and bank were dredged away and revetted at side and end. A channel was left with 11½ feet of water.

Appropriated March 3, 1873..... \$25,000

1873 and 1874.—Six cribs of 50 feet each were built and sunk this season, and a small part of the superstructure placed thereon. One crib (the outer) lightened up late in the fall of 1873, and rolled over into the channel. There was 6,520 cubic yards of dredging accomplished, mostly of sand and slabs from old pier, with a little from the channel-way.

The escaped crib has not yet been replaced. Most of the superstructure has been put on the five remaining cribs of last season.

Appropriated June 23, 1874..... \$20,000

Twenty-five thousand four hundred and forty was estimated to complete the interior work, of which \$20,000 is now appropriated. To construct the remaining 200 feet of pier-extension will cost the unappro-

priated balance, \$15,000. This, with the \$5,440 for interior work, will suffice to complete the estimated improvement.

Channel-dredging will be necessary, and \$10,000 may be required for that purpose.

Parties at this point are very anxious to have a channel-way with 13 to 13½ feet of water, to accomplish which it will be necessary to extend the crib-piers.

It is thought that, with the use of the Government machinery now at work here, the entire removal of the south bank and the revetment of the exposed face will be accomplished with the available funds.

The original estimate for this work was \$270,682.12. There was appropriated—

In 1867	\$50,000
In 1868	31,500
In 1870	10,000
In 1871	10,000
In 1872	10,000
In 1873	25,000
In 1874	20,000
Total	156,500

Financial statement.

Balance in Treasury of United States July 1, 1873	\$25,000 00
Amount in hands of officer and subject to his check	3,864 17
Amount appropriated by act approved June 23, 1874	20,000 00
Amount expended during the fiscal year ending June 30, 1874	19,414 68
Amount available July 1, 1874	27,866 83
Amount required for the fiscal year ending June 30, 1876	10,000 00

Statement of vessels entered and cleared at Ludington Harbor, Michigan, from July 1, 1873, to July 1, 1874.

Entered: number, 746; tonnage, 86,101; men, 3,982.

Cleared: number, 743; tonnage, 96,146; men, 4,063.

An increase over last year of about 30,000 tons.

C 4.

PENTWATER HARBOR, MICHIGAN.

The original plan adopted: To increase width of outlet from 76 feet to 150 feet, and dredge to a depth of 12 feet throughout, involving the removal of 127,028 cubic yards earth and sand; to construct 2,120 running feet pier-work, (1,280 feet on each side.) Estimated cost, \$327,713.40.

Appropriated for 1867

\$55,000

1867 and 1868.—Work commenced latter part of July, 1867, and during the year 320 feet of pier was built (10 cribs) in extension of the south pier, and 15,944 cubic yards of earth removed from channel.

1868 and 1869.—During this fiscal year the south pier was further extended 256 feet, and 22,632 cubic yards earth removed from between piers.

Appropriated in 1869

\$18,000

To complete improvements an estimate of \$40,000 was made, and recommended to dredge away slab-revetment on the south side of entrance.

1869 and 1870.—A north pier (600 feet) was built during the year.

The recommendation of last year, viz., to dredge away slab-revetment, \$40,000 estimated, was renewed.

Appropriated July 11, 1870..... \$10,000

1870 and 1871.—During the year the superstructure over north pier was finished and south pier fully repaired. Two hundred and sixty-one dollars and seventy-three cents was covered into the Treasury by act July 12, 1870.

Appropriated March 3, 1871..... \$10,000

1871 and 1872.—A pier-head, 30 feet square, for north pier, was sunk, and 95 feet of pile-work connecting the south pier with the shore constructed, and channel dredged to 12 feet of water.

Appropriated June 10, 1872..... \$30,000

1872 and 1873.—During the year the whole of old slab-revetment (south) was removed a length of 1,382 feet, with dredging along the face exposed, increasing least width from 75 to 115 feet. Removed a large quantity of sand from channel (62,882 cubic yards) and built 1,042 feet pile-revetment on south side, except a portion of top timbers of last 300 feet, and the filling incomplete.

Appropriated March 3, 1873..... \$20,000

The contract with T. Stewart White, September 2, 1872, was completed August 19, 1873. The top timbers and entire filling of the 300 feet of revetment left incomplete at date of last report was finished that date.

Under the second contract (May 15, 1873) with the same party, two cribs for north pier were placed (100 feet) in extension of the north pier, and superstructure built over them, which still requires an additional weighting of stone.

In the last report 150 feet of pier-extension was said to be required, to be added to either pier as might be found necessary.

No appropriation is asked this year.

The original estimate called for \$327,713. There was appropriated—

In 1867	\$55,000 00
In 1869	18,000 00
In 1870	10,000 00
In 1871	10,000 00
In 1872	30,000 00
In 1873	20,000 00

Total	143,000 00
Less amount covered in Treasury	261 73

142,738 27

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$20,000 00
Amount in hands of officer and subject to his check.....	10,003 55
Amount expended during the fiscal year ending June 30, 1874.....	23,639 51
Amount available July 1, 1874.....	6,364 04

Statement of vessels entered and cleared Pentwater Harbor from July 1, 1873, to July 1, 1874.

Entered: number, 453; tonnage, 48,467; men, 3,460.

Cleared: number, 470; tonnage, 45,077; men, 3,556.

A falling off of about 40,000 tons the last year.

C 5.

WHITE RIVER HARBOR, MICHIGAN.

The plan adopted for the improvement of this harbor was to make a new cut about 1,200 yards south of the (present) small entrance. At the

proposed point only a very narrow strip of land, with but slight elevation, separated the two lakes, leaving but 1,250 feet between the 12-foot curves of each lake. To cut this out 200 feet wide and 12 feet deep, protect the banks with sheet-piling, and for pier-work, it was estimated the cost would be \$170,530.80.

Appropriated 1867..... \$57,000

1867 and 1868.—Dredges commenced work in July, 1867, and up to close of the year 105,377 cubic yards of earth and sand was removed, and about 1,000 running feet of close piling built.

1868 and 1869.—No work, except the driving of a few piles, was done during this fiscal year.

1869 and 1870.—One thousand five hundred and sixty-two feet of pier was built and 64,067 cubic yards of earth dredged, leaving a channel of 8½ feet and over, where the preceding year was but 3 feet.

Allotted \$45,000

1870 and 1871.—Two hundred and fifty-six feet was added to the north pier and superstructure continued thereon, as well as piles driven for 64 feet more pier. A channel of 10 feet water was obtained.

Appropriated July 11, 1870..... \$20,000

Appropriated March 3, 1871 20,000

1871 and 1872.—The superstructure of north pier, over the 64 feet of piling mentioned in previous report, was put on and carried on a farther distance of 96 feet on piles driven since then. Piles were also driven for a 40-foot square section intended for a pier-head.

On the south side the pier was prolonged 68 feet, beyond which the piles were driven for a further extension of 28 feet. The filling in the piers about the shore-line was thoroughly overhauled.

Appropriated June 10, 1872..... \$10,000

REMARKS.

To make the piers complete, as originally designed, the south pier should be extended 136 feet, even with the north pier, at a cost of \$6,940.

1872 and 1873.—The work accomplished this year consisted of superstructure on 28 feet of piles, ballasting both piers with brush and stone, carrying a fender-strip along channel-face of north pier, and dredging the channel. No pier-extension was made, owing to the imperative need of dredging.

Appropriated March 3, 1873..... \$7,000

RECOMMENDED.

A permanent improvement demands that the south pier shall be extended 450 feet, to 164 feet water, at a cost of \$48,000.

The south pier lacks 104 feet of completion, as designed in 1870.

The United States dredging-apparatus removed 20,680 cubic yards of sand, &c., from the channel during the year.

1873 and 1874.—During the year the work at this harbor has been limited to making repairs, filling piers with brush, slabs, and stone-ballast.

Appropriated June 23, 1874 \$10,000

With this last appropriation it is intended to put out a crib, 50 by 24 feet, in prolongation of the south pier; obtain 300 cords of slabs and 200 cords of stone for filling and ballast. A portion of this appropria-

tion will be held over for dredging should such contingency occur, as appears likely.

To carry out the permanent improvement suggested in 1873, that is, pushing the south pier into 16½ feet water and the north pier into 11 feet, \$44,525.60 will be required, which, together with \$5,000 for dredging, (mentioned in last report,) will make \$49,525.60, which amount could be profitably expended during next fiscal year.

The original estimate for this harbor was \$170,538.80. Amounts appropriated as follows:

In 1867	\$57,000
In 1869	45,000
In 1870	20,000
In 1871	20,000
In 1872	10,000
In 1873	7,000
In 1874	10,000
Total	169,000

Financial statement.

Balance in Treasury of United States July 1, 1873	\$7,003 53
Deduct amount expended in last fiscal year	1,907 91
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874	4,449 73
Amount available July 1, 1874	10,645 89
Amount required for the fiscal year ending June 30, 1876	49,525 60

Statement of vessels entered and cleared at White River Harbor from July 1, 1873, to July 1, 1874.

Entered: number, 927; tonnage, 111,744; men, 4,506.

Cleared: number, 926; tonnage, 111,617; men, 4,500.

An increase over last year of about 36,000 tons.

C 6.

MUSKEGON HARBOR, MICHIGAN.

Original plan: It was recommended that an extension of the piers be made in a line of direction parallel to the inner face of south pier, (south 61° 31' west,) commencing at the present extremities, until a depth of 17 feet is reached.

Requiring 700 feet of pier-work; estimated cost, \$58,450.

Appropriated March 2, 1867..... \$59,000

1866 and 1867.—Nothing done during fiscal year.

Engineer in charge recommends:

That upper portion of present slab-piers be replaced by a crib-superstructure, stone-ballast, to cost \$64,000.

But there appeared no necessity therefor, and no appropriation was asked.

1867 and 1868.—During the year 384 feet of pier was built, (12 cribs,) work having commenced in July, 1867.

Ten thousand dollars was asked for the next fiscal year to build upper part of a portion of the old piers.

1868 and 1869.—During the year two cribs, 32 feet each, were placed in extension of the north and one in extension of the south piers, and superstructure on all completed. Twenty-eight thousand dollars was estimated to replace superstructure (crib) over slab-work in repairs to interior of crib-pier.

1869 and 1870.—The north pier was extended 320 feet and south pier rebalasted, and repairs to breach between east end of south pier and old slab-pier repaired.

Appropriated July 11, 1870..... \$10,000

The estimate of \$28,000 recommended.

1870 and 1871.—The superstructure over cribs sunk in 1869 was finished, and one crib, 32 feet square, placed as pier-head on north pier, and the north and south piers repaired; the south pier rebalasted.

Appropriated March 3, 1871..... \$15,000

The estimate, \$28,000, again put forward; also for \$4,000 to purchase stone to rebalast north pier.

1871 and 1872.—The construction of a pier-head, 32 feet square, with superstructure over it, and the two cribs sunk in 1869-'70, left the north pier complete. A breach through slab-pier, where it joined south Government pier, was closed with 34 feet pile-pier.

Appropriated June 10, 1872..... \$10,000

No further appropriation was asked.

1872 and 1873.—Under contract with Bird & Mickle the superstructure of north pier-head was rebuilt in October, 1872. During fiscal year there was accomplished under this contract: Piling, two rows, complete, for 250 feet south pier; waling and binder on channel-row and first course of timber complete for 150 feet of pier.

An extension of the south pier 400 feet into the lake, at a cost of \$56,000, was strongly recommended.

1873 and 1874.—The work under contract with Bird & Mickle was completed September 30, 1873, by converting old slab-piers into pile-piers, 350 feet on south and 250 feet on north side of channel, with necessary repairs.

In last report \$56,000 was asked to extend south pier out into the lake to 18 feet water; and of this amount \$10,000 was appropriated, which will be expended the coming season in extending the south pier 50 feet, (one crib,) and making certain needed repairs, especially necessary on north side, east of work of last year, where old slab-pier was burned and where a threatened breach is imminent.

Amount required \$46,000, which can be profitably expended in fiscal year ending June 30, 1876.

The original estimate called for \$58,450. There has been appropriated—

In 1867.....	\$59,000
In 1870.....	10,000
In 1871.....	15,000
In 1872.....	10,000
In 1874.....	10,000
Total	104,000

Financial statement.

Amount in hands of officer and subject to his check.....	\$9,778 40
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	9,698 43
Amount available July 1, 1874.....	10,009 97
Amount required for the fiscal year ending June 30, 1876.....	46,000 00

Statement of vessels entered and cleared at Muskegon Harbor during the year.

Entered. number, 2,479; tonnage, 460,386; men, 19,700.

Cleared: number, 2,570; tonnage, 462,443; men, 20,001.

An increase of about 30,000 tons over the last year.

C 7.

GRAND HAVEN HARBOR, MICHIGAN.

Appropriated in 1852, \$20,000, as per copy of letter to Senator Ferry, dated Office Chief of Engineers, June 23, 1873. As given in tabular statement accompanying report of Chief of Engineers, 1866, \$2,000.

Plan of improvement, (Colonel Graham, 1857:)

To defend the concave bend in the southern shore of the river below the town by a close-piling, and to build two parallel piers out into the lake in prolongation of the river-channel; the south pier by cribs for 600 feet.

Appropriated June 23, 1866 \$65,000

Of this amount, \$11,241.22 was expended in repairing 309 feet of pile-pier on south side, (built by railroad company in 1857.)

The following estimates were given:

1. To include close-piling and repairs of piers.....	\$31,967 42
2. For extension of south pier	61,902 57

93,869 99

Deduct balance of appropriation.....	53,758 77
--------------------------------------	-----------

40,111 22

3. For construction of north pier.....	258,900 48
--	------------

Total	299,011 70
-------------	------------

1866 and 1867.—Work commenced in June, 1867. Six cribs, each 32 feet, were placed in extension of south pier, and 500 feet close-piling constructed.

Appropriated March 3, 1867 \$40,000

It was recommended that the building of north pier be not deferred. Estimated cost, \$200,000.

1867 and 1868.—During this year 1,943 feet of close-piling was finished, and two cribs, 32 feet each, placed in extension of south pier.

1868 and 1869.—The south pier was extended 100 feet, and old pile-work, interior to that part of same pier, (D. and M. railroad,) repaired in 1866, repaired for a distance of 465 feet.

Allotted April 10, 1869.....	\$1,866
------------------------------	---------

Transferred from Frankfort	1,885
----------------------------------	-------

It was recommended—

To complete the improvement a pier on north side is necessary, and repairs to old pile-pier continued for an additional length of 600 feet. The north pier to be 1,700 feet long, to cost \$200,000; and cost of repairs to old slab-pier, \$14,000.

1869 and 1870.—461 feet of old pile-pier was repaired, inward from work of 1866. A crib, 32 feet by 20 feet, was placed to protect the shoulder made by the pile-pier where it joined the crib-work.

Appropriated July 11, 1870.....	\$10,000
---------------------------------	----------

Recommendation for north pier again made.

1870 and 1871.—During this year about 200 feet of old pier was repaired.

Appropriated March 3, 1871.....	\$6,000
---------------------------------	---------

Additional estimates were made as follows: Additional repairs and reballasting necessary to crib-work, \$5,300; repairs to pile-revetment, (of July, 1867,) \$36,000; also, a pier-head to south pier, \$7,000.

Recommendations for north pier again put forward.

1871 and 1872.—During season 460 feet of repairs were completed.

Appropriated June 10, 1872	\$15,000
----------------------------------	----------

The recommendations made in former reports: for a pier-head, \$7,000; north pier, \$200,000; and repairing and replacing inner revetment, which would need a further appropriation of \$26,300; total, \$233,300, were again renewed.

1872 and 1873.—During this year 700 feet pile-revetment, 14 feet wide, was constructed, to replace old work built by the railroad company; and repairs put upon south pier, consisting of overhauling and replacing of filling and ballast, which had become displaced by heavy seas, putting in additional filling, and protecting pier-head crib with upright timbers, and piling and leveling superstructure.

A break in pier under bell-house and another at shore-line were also repaired.

Appropriated March 3, 1873..... \$75,000

It was suggested that old revetment be repaired and maintained, a new work be constructed, cutting off bend in river-bank in a line with work of 1872.

1873 and 1874.—The United States dredging-apparatus had removed sufficient sand on the line of proposed north pier to enable the contractors, Messrs. Squier and White, to commence driving piles on the 7th July, 1873, under contract dated May 15, 1873, providing for the construction of the first three sections of north pier, 21 feet.

The weather throughout the entire season was most favorable for outside work, and on the 29th November the last pile of the revetment and close-piling (1,506 linear feet of pier) was driven, much of the superstructure placed thereon, 700 feet of the work filled with slabs to the required height above water, and a cargo of stone placed on the filling at the pier-head, as completed, to hold the filling in place through the winter.

On the 8th of April, 1874, dredging was commenced on the line of the proposed 20-foot pile-pier or outer section of north pier, and was completed June 18. On the 19th June the apparatus left this harbor for Ludington, having removed 45,488 cubic yards of sand in connection with this entire work.

The contractors, on May 4, commenced driving the piles for the outside work, and have pushed matters so that only 250 piles remain to be driven to complete that part of the work.

Much of the filling has been placed in this work to the water-surface, and some stone placed thereon to secure it.

The superstructure is well advanced and nearly completed for one-half the section, viz., 300 feet.

The alignment of the whole work, considering the very awkward action of the piles in driving, is very good, and the work is certainly substantial, as the average depth of the dredge-cut was about 16 feet, and the average depth of driving a trifle over 13 feet.

The extremely rough and continuous northwest weather of last fall caused the formation of a bar on the prolongation of the north-pier line, upon which bar, for the first 200 feet from the pier, there was not to exceed 3 feet of water. This bar was also driven over into the channel-way, so as to leave only about 200 feet of water-way available during the winter and early spring. It has, however, gradually worn away, so that with the dredging and the action of the current it is so reduced as to no longer interfere with navigation.

The same rough weather carried out the filling from the open pile-work at the "bell-house" (south pier) for a space nearly 100 feet in length, leaving a depth of from 1 to 4 feet of water through the pier.

This, with the loss of smaller amounts of filling at different points farther east in the work, is about the extent of the damage done.

Some repairs in the shape of overhauling and refilling were put upon this pier immediately after the last fiscal year.

The machinery of the United States dredge and tug received some considerable repairs at this harbor during the winter months, and the dumping-scows were hauled out and received repairs amounting nearly to a rebuild. These repairs were very much needed, as the hulls had been in use four seasons, during which time they had not been overhauled.

The new dump-doors were furnished with a hinge, which so completely confines sand in the hoppers that not the least escape can be detected.

The present season opened very late, and has been productive of more rough weather than is common to the early months. The progress of the work has been much impeded in consequence.

All materials are on hand, however, and bad weather is the only cause of delay.

In May last I directed such survey and examination of Grand Haven Harbor as would develop any changes which might have taken place since the survey of 1871.

A comparison of the two surveys shows some very marked changes, both as to depth of water and shore-lines.

As will be seen by reference to sketch accompanying my project for this season's work, June 30, 1874, the shore-line on the north side makes the pier at a point 12 feet east from the outer angle of the work, and extends to the northward in a regular line, giving a good beach, from which the water deepens gradually as on the south side.

This shore-line has been and is advancing very rapidly, and has nearly reached the general line of beach, as prolonged from the northward of the harbor.

The sand is rapidly filling in behind the north revetment, and will undoubtedly bear against the work soon after all the filling is placed and settled.

The depth of water developed outside the piers shows a water-way averaging nearly 350 feet in width, in which not less than 20 feet depth is found, and which holds good on the ground but lately occupied by a 16-foot bar, which is certainly satisfactory, and especially so when the fact is considered that there had been no freshet worthy of note, in fact scarcely any at all, prior to the time at which this survey was made.

This increased depth of water may be fairly considered as the direct consequence of confining the ordinary volume of discharge of Grand River to a 400-foot width of way by means of a north pier.

At a point on the north side of Grand River, at the old railroad dock, just opposite the town, sand has blown over in such quantities that quite a bank has formed, projecting more than a foot above the level of the water. Although there is but little, if any, current at this place at present, in times of freshets the whole bar or bank might be carried off into the channel.

About half a mile above the town, on the north side of the river, the constantly-accumulating sands have assumed the character of a landslide, which is about to force into the stream the revetment along the line of the deserted track of the Detroit and Milwaukee Railroad. Several breaks already exist in this revetment, and should it give way altogether, which it must soon do, it may cause some annoyance to navigation.

The lands on the north side, for a distance of a mile above town, are

entirely in disuse, and there is consequently no incentive for private enterprise to undertake a protection of the bank of the river at this place.

It would seem that something should be done to protect the harbor from encroachments of sand from this source.

This year the north pier will be extended 300 feet, terminating it opposite a point about 100 feet short of the end of the south pier. On the south side 500 feet of revetment, eastward of and on a line with the work of 1872, will be built, cutting off the point where the waterway is contracted some 75 feet.

The original estimate for this harbor (1866) amounted to \$299,011.70.

There has been appropriated as follows :

In 1852	\$20,000 00
In 1866	65,000 00
In 1867	40,000 00
In 1869	1,866 00
In 1870	10,000 00
In 1871	6,000 00
In 1872	15,000 00
In 1873	75,000 00
In 1874	50,000 00
	282,866 00
Transferred in 1870, Frankfort	1,885 00
Total	284,751 00

Financial statement.

Balance in Treasury of United States July 1, 1873	\$75,000 00
Amount in hands of officer and subject to his check	6,305 76
Amount appropriated by act approved June 23, 1874	50,000 00
Amount expended during the fiscal year ending June 30, 1874	51,595 20
Amount available July 1, 1874	79,710 56

Statement of vessels entered and cleared at Grand Haven Harbor during the year.

Entered : number, 1,350 ; tonnage, 443,114.
 Cleared : number, 1,341 ; tonnage, 439,522.

C 8.

BLACK LAKE HARBOR, MICHIGAN.

The plan of improvement for this harbor was to extend north pier 250 feet, and south pier 275 feet, to bring them into 12 feet of water. At the entrance to Black Lake the channel to be close-piled for 1,125 feet on north and 425 feet on south sides, to reach 12-foot curve. The channel between the piers (built by the citizens of Holland) and extensions to be dredged to a depth of 12 feet, requiring the removal of about 80,000 cubic yards, to include removal of point of marsh through which sheet-piling will pass.

Amount required to complete harbor, estimated :

For dredging	\$28,935 33
For piling	43,220 48
For close-piling	15,745 23
For sheet-piling	18,337 00
Total	106,238 04
Appropriated in 1866	55,615 31

1866 and 1867.—Dredging was commenced August 6, 1867, and during season about 15,000 cubic yards material removed. Up to June 30, 1868, 81,945 cubic yards sand was dredged in making required channel, and 352 feet pier built.

Appropriated in 1867 \$51,000 00

No further appropriation was asked.

1867 and 1868.—Four cribs were placed on north side, and 22,650 cubic yards sand dredged.

1868 and 1869.—During this fiscal year 5 cribs, 32 feet by 20 feet each, were placed on line of south pier, extending it 160 feet, and 1 crib of same dimensions on north pier, with the superstructure finished.

1869 and 1870.—The north and south piers were repaired, and a pier-head (32 feet square) placed to protect south pier; 575 feet of revetment was constructed to protect channel bank on north side of upper end of the cut.

Appropriated July 11, 1870 \$10,000 00

It was recommended, as imperatively necessary, torevet the sides of the cut; the length of revetment, 530 feet on north and 900 feet on south side of channel; to cost \$25,801.75. Also, a recommendation that \$5,000 be given to dredge channel.

1870 and 1871.—During the year a crib 32 feet square, built up to water-surface, was placed at end of north pier; 100 feet of crib-work, connecting inner end of south pier with shore-line, also built.

Appropriation March 3, 1871 \$10,000 00

It was suggested "that the revetment to channel-way should be finished as soon as practicable." Eight hundred and fifty feet close-piling, in addition to what was under way, was required; cost, \$12,500.

1871 and 1872.—During this season 640 feet of pile-revetment was completed, 320 feet on each side of the cut inward from the ends of the old piers. The superstructure of 100 feet of crib-work at inner end of south pier (begun in 1870) was finished; also the pier-head crib to north pier. A protection of piles was constructed around the north pier-head.

Appropriation of June 10, 1872 \$10,000 00

REMARKS.—That the former estimate for this work (revetment of the cut) was deemed insufficient, and that there would be needed, in addition, \$7,000 to complete it, and \$5,000 for dredging and contingencies; total, \$12,000.

1872 and 1873.—The United States dredging-apparatus commenced work in August, 1872. Up to September 9, 1872, 15,660 cubic yards of sand was removed; but the day after the dredge left the harbor a heavy blow set in, continuing some days, leaving the harbor in the same condition as before dredging commenced, viz., 6 feet water in mid-channel.

Four hundred feet of revetment was built on north and south sides of channel, 200 feet on each side, and repairs put upon both piers, consisting of overhauling filling and filling spaces between cribs, and some stone put in north pier-head.

In the spring of 1873 but 6½ feet of water was found in the channel. No dredge was available, so the steam-tug Tempest was engaged to remove the sand with her wheel; 16,866 cubic yards was removed in this manner, leaving the channel with very level bottom for whole space between piers, and allowing vessels to enter in 10½ feet water.

Appropriated March 3, 1873 \$12,000 00

The extension of both piers 300 feet during next year, (1874,) which

would leave the mouth of the channel in 15 feet water, was recommended, at an estimated cost of \$50,000.

1873 and 1874.—Messrs. Culbert & Hopkins, under contract providing for the building of 400 feet of revetment, 14 feet wide, completed their work October 4, 1873.

This work consists of a projection of the south revetment 90 feet eastward, and of 328 feet of revetment, forming a wing to, and at an angle of $67^{\circ} 30'$ south from, the south revetment in Black Lake.

After the close of the contract-work the foreman was instructed to procure shingle-cuttings, with which to replace some of the filling in the revetments on either side of the channel.

The cuttings were placed very carefully, and being mixed in with the slabs before used, have served the purpose for which they were intended, viz., to keep the sand from working through and under the coarser filling.

Through lack of funds it was found necessary to suspend this work of repairs, which should be prosecuted under the present year's appropriation, and the overhauling made thorough and complete.

The developments of a survey recently made show this harbor to be in better condition, in all regards, than at any spring examination heretofore made, save that of 1870, when from 12 to 13 feet of water was found. This was caused by the formation of a barrier of grounded ice across the mouth of the harbor in the month of January, 1870, which barrier suddenly giving way allowed the heavy accumulation of water in Black Lake to pass into Lake Michigan, which it did in one night, scouring the sand from the channel so as to leave the depth of water above stated.

An extension of the piers is necessary in order that the entrance to the harbor may be in water of such depth that the action of seas will not form bars so readily across the mouth from the sands swept from the shoals behind the piers.

The present year's appropriation will help this harbor considerably, but until the pier-heads stand in about 15 feet of water it is thought this trouble from bars will continue.

It is intended this year to extend both piers out into the lake as far as the funds will admit.

Appropriation June 23, 1874..... \$15,000 00

The original estimate called for \$106,238.04. There has been appropriated :

In 1866	\$55,615 31
In 1867	51,000 00
In 1870	10,000 00
In 1871	10,000 00
In 1872	10,000 00
In 1873	12,000 00
In 1874	15,000 00
Total	163,651 31

Financial statement.

Balance in Treasury of United States July 1, 1873	\$12,007 35
Amount in hands of officer and subject to his check	1,042 38
Amount appropriated by act approved June 23, 1874	15,000 00
Amount expended during the fiscal year ending June 30, 1874	12,720 76
Amount available July 1, 1874	15,328 97
Amount required for the fiscal year ending June 30, 1876	35,000 00

Statement of vessels entered and cleared at the harbor of Black Lake during year.

Entered: number, 500; tonnage, 31,340.

Cleared: number, 500; tonnage, 31,449.

The same number of vessels as the year before, showing that a larger class of vessels make this port than formerly.

C 9.

SAUGATUCK HARBOR, MICHIGAN.

Previous to the Government survey (in 1866 and 1867) and examination at this harbor, the citizens had expended considerable money in endeavoring to improve it. At that time they had a good slab-pier on each side of the channel, extending 500 feet on the north and 1,575 on the south, giving them a channel of about 7 feet.

The project approved for the improvement of this harbor was to extend the south pier 416 feet, and the north 1,632 feet, carrying their ends into 12 feet water—these piers to be parallel to each other and 200 feet apart—and to dredge a channel between them to a depth of 12 feet. Also, to cut a channel in the bay 200 feet wide and 12 feet deep, to connect with the deep water near the first bend.

Estimated cost, in total..... \$203,295 80

1868 and 1869.—No Government improvement had been undertaken up to this time, but a commission was appointed to examine and report upon further or other improvements suggested by Bvt. Lieut. Col. F. U. Farquhar, viz., to revet the left or south bank at the bend, then continue that revetment to the east end of south pier. On the north side he proposed to build 1,660 feet of revetment, 770 feet close piling, and 6 cribs of 32 feet each, at a cost of, for both sides, \$86,398.48. This estimate included 60,740 cubic yards of dredging.

Allotted in 1868..... \$23,900 00
Allotted in 1869..... 6,100 00

30,000 00

1869 and 1870.—During this season 1,200 feet of revetment was completed.

Appropriated July 11, 1870..... \$10,000 00

An estimate for \$6,000 made to secure the long slab-pier on the south side.

The recommendation was renewed that the north pier be carried out as soon as possible.

1870 and 1871.—The revetment was completed as far as east end of south pier.

Appropriation March 3, 1871..... \$10,000 00

1871 and 1872.—The work of protecting the south slab-pier for a length of 365 feet was finished. Some refilling in work of 1870 found necessary.

Appropriation of June 10, 1872..... \$15,000 00

Recommendation for north pier and revetment was renewed.

1872 and 1873.—The south-side revetment was completed. Some slight repairs were made to the piers by hired labor.

The piles for the 280 feet of pile-pier on south side of channel were about all driven and some superstructure put on. Fender-piles were

driven to protect vessels against protruding bolt-heads in waling. Materials at contract-prices and work performed by hired labor. A contract was entered into with John Roost for 400 feet of close piling for north pier, but not commenced upon at the close of the fiscal year.

Appropriation March 3, 1873 \$10,000 00

1873 and 1874.—The superstructure on the south 280 feet of pile-pier was completed.

Upon my recommendation, and by the authority of the Chief of Engineers, dated August 27, 1873, the contract with John Roost for 400 feet of close piling for north pier was annulled, and the work is now being prosecuted by hired labor. Piles for about 175 feet of this work have been driven.

The wing-dam proposed in my last report, and authorized by the Chief of Engineers, was built late in the fall. It is 243 feet long, and answers well the purpose for which it was intended.

The threatened breach in the revetment at the bend in the river has been very thoroughly strengthened by anchor-piles driven in rows through and across the work, to which the cross-ties are bolted, and in two cases where the greatest bulge occurs, these rows of piles have been carried well to the rear, and heavy timbers bolted on and carried through to the waling and top timbers of the revetment.

The construction of the dam in the river above has apparently to some extent destroyed the agency which tended to undermine the revetment at this place, and to its presence I attribute the shoaling of the water to 18 and 24 feet, where formerly 27 and 30 feet prevailed.

The counter revetment proposed before, and which met with your approval, may, I think, be safely abandoned; at all events, for the present.

Appropriation of 1874 \$10,000 00

With the appropriation of this year it is proposed to build about 400 feet of revetment, necessitating the dredging out of part of old slab-pier on north side, thereby making thorough connection of the north pier, now constructing, with the shore. Some repairs are needed where filling has been washed out, which will receive attention before winter.

I ask an appropriation of \$15,000 for continuing the improvements here.

The original estimate was \$203,295.80, and there has been appropriated:

In 1868 and 1869	\$30,000 00
In 1870	10,000 00
In 1871	10,000 00
In 1872	15,000 00
In 1873	10,000 00
In 1874	10,000 00
Total	85,000 00

Financial statement.

Balance in Treasury of United States July 1, 1873	\$20,000 00
Deduct amount expended last fiscal year	906 18
Amount appropriated by act approved June 23, 1874	10 000 00
Amount expended during the fiscal year ending June 30, 1874	13,818 08
Amount available July 1, 1874	15,275 74
Amount required for the fiscal year ending June 30, 1876	15,000 00

Statement of vessels entered and cleared Saugatuck Harbor during the year.

Entered: number, 576; tonnage 77,120.

Cleared: number, 577; tonnage 77,711.

C 10.

SOUTH HAVEN HARBOR, MICHIGAN.

In November, 1866, a survey of this harbor was made. At that time the river (South Black River) was but 85 feet wide at its mouth and 7 feet deep between the piers. The piers were built by citizens of the neighborhood, and cost about \$18,000. The banks of the river, for 500 feet on each side, had a protection of rough close-piling.

The plan proposed to improve this harbor was:

To extend two parallel piers, 120 feet apart, having a direction of south $84^{\circ} 30'$ west from the mouth of the river into 12 feet water.

There were two plans: one to extend the piers until 12 feet depth was reached, and then dredge a channel across the bar, (which was 750 feet from entrance to the harbor, and upon which there was 9 to 10 feet water.) The other plan was to extend the piers over the bar into 12 feet water.

The plan first mentioned was recommended and adopted. It contemplated widening the mouth of the river to 120 feet, protecting the banks of the river by sheet-piling, building 1,088 feet pier-work, dredging the whole water-way between piers to 12 feet water, and dredging a channel across the outer bar.

The estimated cost of this improvement to be..... \$128,285 47

1866 and 1867.—During year nine cribs were placed.

Appropriated in 1867 \$43,000 00

1867 and 1868.—Work done to 28th June, 1868, consisted in placing 12 cribs, 8 on south side, and on this side the superstructure was commenced.

1868 and 1869.—During fiscal year 8 cribs (32 by 20 feet) were placed on prolongation of north pier, and superstructure over them. The outer crib of this pier, which was carried away by a storm in the spring, (1869,) was replaced and ballasted with stone.

It was recommended:

To complete the proposed improvements of this harbor, the piers should be extended each 400 feet, at a cost of \$52,000. The old slab-pier should be removed to widen the entrance to the river, and the channel dredged to a depth of 12 feet. These two items would cost \$30,000.

1869 and 1870.—No work was done during the year.

Appropriation July 11, 1870 \$10,000 00

The recommendations contained in previous report (1869) were again put forward. Estimated to cost for extension of each pier 400 feet, \$54,000, and to remove old pier and dredge channel, \$30,000.

1870 and 1871.—During the year a crib 30 feet square was built and placed at head of north pier, and the pier leveled up; also, 1 crib, 50 by 32 feet, placed in extension of south pier.

Appropriation March 3, 1871 \$15,000 00

It was recommended that no further extension of the piers be made beyond what was then under contract, and "in lieu of the plans already recommended," it was proposed to widen the channel by dredging out the north bank and constructing a pile-revetment. The channel-way to be deepened to 12 feet water. Estimated cost—for dredging, \$32,000; pile-revetment, \$12,138.33.

1871 and 1872.—Under contract with George Hannahs, three cribs were sunk, one on south and two on north pier. Eight thousand

four hundred and thirty-one cubic yards of dredging was done by the United States machinery up to July 1, 1872.

Appropriation June 10, 1872 \$12,000 00

The following appears in the report for this year, (1872 :)

To complete the work of this harbor, as designed and recommended in former years, will require—

For pier-extension	\$55,000 00
For dredging and removing slabs	32,000 00
For building revetment	12,138 33

Total	99,138 33
-------------	-----------

1872 and 1873.—During this year the harbor was dredged by the United States machinery to 10 feet water. Also, a displaced crib was resunk, one new crib added to north pier, and repairs put upon south pier.

Appropriation March 3, 1873..... \$20,000 00

The recommendations contained in report of 1872 were renewed, and the estimate, less the \$20,000 appropriated, was thought sufficient to meet all demands.

1873 and 1874.—The contract with James Caldwell, which provided for the re-sinking of an old crib, and the building and sinking of another, with superstructure for both, was completed November 8, 1873, the work being satisfactory.

Work under contract with William Nicolls was commenced in June, 1873, and the first crib sunk July 26, 1873, the second August 2, and the third August 9, 1873.

This contractor seemed to experience considerable difficulty in pushing his work forward, so at the end of the season, the work being in part without superstructure, was left for completion in the spring of 1874.

On the 18th of November, 1873, during the heavy northwest storms which prevailed at that time, the crib at the head of north pier was driven from its place, and moved up the channel about 300 feet, where it grounded. It was secured to the north pier by heavy cable-chains, and left for the winter.

During a heavy blow soon after, it parted its chain, when, through the direction of Hon. George Hannahs, a citizen of the place, it was buoyed up, and floated up the channel to a place of safety.

On the 13th of March, 1874, a heavy storm moved the crib at the head of the south pier from its place, and drove it upon the beach south of the harbor, where it brought up at about 300 feet south from the south pier and about the same distance from the shore, and was immediately surrounded by sand, upon which there was not to exceed $5\frac{1}{2}$ feet of water, the crib meantime drawing $11\frac{1}{2}$ feet. The United States tug Col. Graham, with extra anchor and lines, was sent to haul the crib off, which was readily done; the tug's wheel making a channel 300 feet by 50 feet, and 9 feet deep up to the crib, which was at the same time buoyed up, whence it was towed into the harbor.

The sands at this point are very treacherous. It was found upon examining the foundations upon which these cribs rested, that the large amount of stone, over 100 cords to each crib, appeared to be buried in the sand, with from $9\frac{1}{2}$ to $12\frac{1}{2}$ feet of water over them.

These cribs have been re-sunk under the supervision of the United States foreman, and will be superstructured this season.

The depth of water at this harbor is better between the piers than last year, there being an available 9-foot channel from Lake Michigan to the warehouse dock.

No survey was made beyond a few soundings taken by the United States foreman.

Appropriated June 23, 1874..... \$10,000 00

The coming season about 300 feet of revetment on north side will be built.

To continue the improvement will require \$40,000.

Original estimate was \$128,288.47, and there has been appropriated :

In 1867.....	\$43,000 00
In 1870.....	10,000 00
In 1871.....	15,000 00
In 1872.....	12,000 00
In 1873.....	20,000 00
In 1874.....	10,000 00
Total	110,000 00

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$20,000 00
Amount in hands of officer and subject to his check.....	8,250 50
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874	26,190 52
Amount available July 1, 1874	12,089 98
Amount required for the fiscal year ending June 30, 1876	40,000 00

Statement of vessels entered and cleared at South Haven Harbor, Michigan, during the year :

Entered : number, 464 ; tonnage, 27,787.

Cleared : number, 455 ; tonnage, 27,572.

C II.

SAINT JOSEPH HARBOR, MICHIGAN.

From tabular statement in report of Chief of Engineers for 1866, it appears that the following appropriations were made for this harbor, viz :

Appropriated in 1836	\$20,000 00
Appropriated in 1837	15,000 00
Appropriated in 1838	51,113 00
Appropriated in 1843	25,000 00
Appropriated in 1844	20,000 00
Appropriated in 1852	10,000 00
Appropriated in 1864	15,000 00
Appropriated in 1866	6,000 00
	162,113 00

From plans, maps, &c., in this office, I would infer that this money had been expended on 1,100 feet of pier on the north and 212 feet on the south side of the channel.

1866 and 1867.—The old piers underwent some repairs this year and materials were received for extension of south pier.

Allotted, 1867

\$7,500 00

It was recommended to extend south pier by 700 feet at an estimated cost of \$77,000.

1867 and 1868.—Two hundred feet of south pier was built and filled, with exception of the last two sections; these were nearly full, but washed out during a storm.

The recommendation for extension of 700 feet to south pier renewed.

1868 and 1869.—Nothing done this year. It was, however, found that the direction of the piers was a mistake; they should have been placed in the direction taken by the current after it left the end of the south pier, about north 78° west from the west end of that pier. It was therefore suggested, to permanently improve the harbor, the south pier should be extended 928 feet in that direction, and a north pier built parallel to it 940 feet long. These two piers, it was estimated, would cost \$116,666.

1869 and 1870.—No work done during this year for want of means.

The recommendations, as before, renewed. Three thousand dollars should be appropriated for general repairs.

1870 and 1871.—Three hundred and fifteen piles were driven, and a portion of south pier completed.

Appropriated July 11, 1870.....	\$15,000 00
Appropriated March 1, 1871.....	10,000 00
	25,000 00

Later experience proved that the ideas advanced in report of 1869-70 were erroneous, as direction of piers was not changed.

1871 and 1872.—During this year the south pier was extended 416 feet, and some inexpensive crib-work put in to make good the connection between south pier and shore. Considerable filling was necessary in both piers, as well as some repairs.

Appropriated June 10, 1872.....	\$3,000 00
---------------------------------	------------

1872 and 1873.—During year the work consisted of overhauling and replacing filling, putting additional filling in south piers, and building a pile protection at end of north pier. Materials were purchased in open market and work done by hired labor.

1873 and 1874.—Nothing was done.

Appropriated June 23, 1874.....	\$2,000 00
---------------------------------	------------

A survey of this harbor was made in June last. It is evident that the bridge of the Chicago and Michigan Lake-Shore Railroad, which crosses the river here, a little over 1,700 feet from the mouth, is a very decided detriment to the harbor.

The continuous northwest weather of last fall caused a bar to form immediately off the head of the north pier, extending towards the south, and obstructing nearly one-half the entire width of channel-way just outside the piers. The water on this bar shoals to 6 feet, though about 15 feet can be carried elsewhere. It is noticed that very shoal water exists just north of the north pier, and a northwest wind having so full a sweep as it has, must wash these sands in upon the channel-way, tending to form a bar detrimental to the safety of vessels attempting to enter the harbor.

A projection or extension of the north pier seems desirable at this harbor to serve as a breakwater against northwesterners, and as a revetment against the encroachments of sand from the shoals north of the pier.

No appropriation is asked. The \$2,000 just appropriated will be applied at once to the filling and ballasting of the present piers.

Appropriated—

From 1836 to 1866.....	\$162,113 00
From 1866 to 1867.....	7,500 00
In 1870.....	15,000 00
In 1871.....	10,000 00
In 1872.....	3,000 00
In 1874.....	2,000 00
Total.....	199,613 00

Financial statement.

Amount in hands of officer and subject to his check.....	\$155 33
Amount appropriated by act approved June 23, 1874.....	2,000 00
Amount expended during the fiscal year ending June 30, 1874.....	34 76
Amount available July 1, 1874	2,129 57

Statement of vessels entered and cleared at Ponton Harbor during the year.

Entered: number, 293; tonnage, 6,064; men, 652.
 Cleared: number, 297; tonnage, 6,064; men, 637.

St. Joseph Harbor.

Entered: number, 400; tonnage, 88,523; men, 4,042.
 Cleared: number, 403; tonnage, 86,696; men, 4,051.

APPENDIX D.

ANNUAL REPORT OF MAJOR G. WEITZEL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1874.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., August 8, 1874.

GENERAL: I have the honor to transmit herewith my annual reports relating to the works of river and harbor improvements under my charge for the fiscal year ending June 30, 1874.

I am, general, very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

D 1.

SAINT MARY'S FALLS CANAL, MICHIGAN.

Since my last annual report the part of claim No. 68 which was required for the canal enlargement has been purchased by the State board of control, and the title papers to claim No. 76 were perfected and placed on record in the office of the register of deeds for Chippewa County. It was paid for last February. The title-papers to all the land required are, therefore, now held by the Government, except to claim 68, which is held by the State board of control.

During the past year the greatest amount of work was accomplished that has been done in one year since the commencement of the improvement. The winter was very favorable for work, and the contractors took advantage of it.

The canal was closed to navigation on the 19th of November, 1873, by placing a dam across its bed near section 30 west, connected through openings in the piers, by wing-dams with the shore-lines. Leaks through the north wing and the north bank of the canal near section 9 west, which were not stopped until December 10, delayed the work con-

siderably. After this a steam-pump, started near section 18 west, and the one stationed at section 131 easily kept the pit free of water. The excavation of the old channel between section 27 west and section 142 east was almost entirely completed before the opening of navigation, and the building of the pier-revetment was nearly completed at the end of the year; and in a few days the contract with Messrs. Barker & Williams, dated February 9, 1871, will be completed. The one with these parties, dated December 7, 1871, has been completed, and final payment made.

The excavation of the lock-pit for the new locks, which work is under contract with Messrs. Boyle & Roach, dated May 19, 1873, is nearly completed.

The completion of the excavation of pier-revetment from section 142 east the old canal locks will be placed under contract in a few days, and thereafter the stones required for the new lock-walls. It is extremely important and pressing that there should be no delay in constructing these locks. The old locks are breaking in several places, and they stand in need of repair. An attempt on the part of the agents of the State board of control to pump out the water with the aid of caissons this spring failed. If anything should happen to these old locks in the present condition of affairs to prevent their use, the effect on the immense and valuable commerce of the Lake Superior region would be ruinous. The tonnage passing through this canal is steadily on the increase, and the new locks are urgently necessary. Some passenger-steamers, having many passengers and large cargoes on board, are frequently delayed hours in awaiting their turn to pass through. For this reason the whole of the appropriation asked for by me should be granted.

The amount of work done during the year was as follows:

Timber, feet, board-measure, delivered	739, 224
Plank, feet, board-measure, delivered	2, 637
Iron, pounds, delivered	40, 300
Framing, feet, board-measure, done	521, 496
Revetting wall, feet, done	11, 015
Lock-excavation, cubic yards	57, 828
Gravel-excavation, cubic yards	87, 256

The cost of the new locks, as estimated by my predecessor, General O. M. Poe, was in round numbers about \$1,160,000, as shown in detail herewith. This estimate was submitted in December, 1872, and approved.

60,000 cubic feet pine-timber, 30 cents	\$18, 000
1,300 cubic feet oak-timber, 50 cents	650
540,000 feet, board-measure, pine plank and scantling, \$30	16, 200
400,000 pounds wrought iron, 10 cents	40, 000
1,620,000 pounds cast iron, 5 cents	81, 000
10,000 barrels cement, \$3	30, 000
30,000 cubic yards rock-excavation, \$3.50	105, 000
90,000 cubic yards gravel, \$1	90, 000
27,800 cubic yards masonry, \$27	750, 000
1,100 cubic yards concrete, \$10.80	11, 880
30,000 cubic yards embankment, 50 cents	15, 000
500 cubic yards slope walls and paved drains, \$2	1, 000
Total	1, 159, 330

Of this amount \$685,000 have been appropriated for the improvement of the Saint Mary's River and Saint Mary's Falls Canal. Of this amount about \$85,000 have been diverted for the improvement of the river and enlargement and improving of the canal. There remains, then, \$560,000

still to be appropriated under this estimate, and at least \$300,000 of this should be appropriated at once.

It is yet impossible for me to estimate the amount that will be required for the entire and permanent completion of this work. Three hundred thousand dollars can be profitably expended upon this work during the next fiscal year.

The work is situated in the Superior collection district, Michigan, at the Sault Saint Marie subport of entry, and a short distance from Fort Brady. The nearest light-house is at Round Island, and the nearest port of entry is Marquette.

The amount of revenue collected in the Superior district during the last fiscal year was \$6,235.34 coin and \$8,201.38 currency.

The whole commerce of the great chain of lakes will be benefited by the completion of this work.

This report is accompanied by a tracing of a diagram, showing the elevation of the surface of the water on the Saint Mary's Falls Canal above the datum plane of the survey of 1870, during the fiscal year, and another tracing showing the work that was done during the same period.

I desire to add that the whole amount of funds available for this work will be under contract in a short time, and will, probably, barely suffice to purchase the face-stone. A failure to make the appropriation asked for would, therefore, stop the work during a season.

Financial statement.

Balance in Treasury of the United States July 1, 1873.....	\$524, 038 00
Amount in hands of officer and subject to his check, (including \$20,472.52 percentage due on contracts not yet completed).....	118, 584 59
Amount appropriated by act approved June 23, 1874	200, 000 00
Amount expended during the fiscal year ending June 30, 1874.....	261, 599 24
Amount available July 1, 1874	354, 062 81
Amount required for the fiscal year ending June 30, 1876	300, 000 00

D 2.

SURVEY OF HAY LAKE CHANNEL, SAINT MARY'S RIVER, MICHIGAN.

When I relieved my predecessor, Maj. O. M. Poe, Corps of Engineers, last May, I found that he had intended to ask for authority to make this survey. Upon my first visit to this river I was so impressed with the great benefit that would be derived from the improvement of this channel by the large and constantly-growing commerce of the Lake Superior region, that I wrote to you on the 31st of May, 1873, requesting authority to make it, and again on June 30, 1873, submitting an estimate of its cost.

By letter from your office, dated July 31, 1874, I was authorized to make it, and accordingly I organized a party to do the work, under charge of Mr. H. A. Ulfers, assistant engineer. The following is a copy of his report:

Report of Mr. H. A. Ulfers, Assistant Engineer.

DETROIT, MICH., August 6, 1874.

GENERAL: I have the honor herewith to report on the survey of Hay Lake Channel, of St. Mary's River, Michigan, made last fall under your directions.

The object of the survey was to demonstrate the superior advantages of the Hay Lake Channel over the one hitherto used—the Lake St. George Channel.

These advantages are of a two-fold character. An inspection of the general map,

herewith submitted, will show at a glance that Hay Lake Channel offers decidedly the shortest and most direct route from Mud Lake to the Sault Ste. Marie's Canal. The difference in favor of this route amounts to almost precisely eleven miles, being thirty-eight miles by the Lake St. George route and twenty-seven miles by way of Hay Lake Channel.

But this is not the only nor the principal advantage claimed for the proposed new route. It is well known that the Lake St. George Channel is practicable only in daylight, and in bright weather at that, on account of its tortuous course and in many places narrow water-way. No vessel ever thought of passing it in night-time, and if approaching it from either end, a half hour too late to pass entirely through had to lose the whole night on that account.

The plan for opening the Hay Lake Channel is not the most economical one that could have been devised. If the question had been merely to shorten the route from Lake Huron to Lake Superior by eleven miles, advantage could have been taken of deeper water, involving far less excavation, and consequently at much less cost.

But this would have involved a more devious course, and would have defeated the second object, which appears to be of much greater importance, that of affording an opportunity of establishing range-lights, so as to render navigation in night-time feasible. The lines proposed and laid down in the accompanying maps require four sets of range-lights, which, if established, would render navigation in night-time entirely secure, except, of course, in foggy weather.

The following estimates of cost are based on the soundings and borings made during last fall. The water at that time was on an average one foot higher than low water as ascertained by the gauge at the foot of the canal. The soundings were accordingly reduced so as to apply to low water.

The work would have to be divided into four sections, differing from each other in their character.

The first or upper section comprises the Sngar Island Rapids, and partly cuts through several of the numerous islands of that region. The bottom of the river and the soil of the islands is composed of clay, with ridges of small bowlders. From the small number of borings which could be made last fall it is impossible to give the exact proportion of clay and bowlders, but it will not be far out of the way to assume it as two-thirds clay and one-third of bowlders. The calculations have been made accordingly.

The second section embraces the flats at the head of Hay Lake. They are of small extent, and composed entirely of sand.

The region occupied by the third section at the foot of Hay Lake is of much greater extent, but also composed of sand exclusively. Some provision will have to be made here to prevent filling up after the excavation is made.

The fourth section, comprising the West Neebish Rapids, is, although small in extent, by far the most expensive. The bottom consists almost exclusively of limestone rock in thin layers, and has to be taken out by means of coffer-dams. These will, of course, be quite expensive, but as the quantity of rock to be quarried out of each is quite large, I feel justified in estimating the price per cubic yard at four dollars, and expect that it can be done for less.

ESTIMATES.

Section 1.—Sngar Island Rapids:	
760,090 cubic yards excavation, ($\frac{2}{3}$ clay and $\frac{1}{3}$ bowlders,) 40 cents.....	\$312, 036
Section 2.—Flats at head of Hay Lake:	
180,260 cubic yards excavation, (sand,) 25 cents.....	45, 065
Section 3.—Flats at foot of Hay Lake:	
1,223,988 cubic yards excavation, (sand,) 25 cents.....	305, 974
Section 4.—West Neebish Rapids:	
527,046 cubic yards excavation, (rock,) \$4.....	2, 108, 185
Grubbing and Clearing:	
21 $\frac{1}{2}$ acres, partly in small timber and partly in grass, at \$25 per acre.....	537
Range-lights:	
Four sets, at \$20,000.....	80, 000
Total.....	2, 851, 797
Add 10 per cent. for contingencies.....	285, 180
	3, 136, 977

All these calculations are based upon a prism of excavation 300 feet wide at the surface, with a slope of 2 $\frac{1}{2}$ to 1. In the case of the rock excavation this might properly

be reduced to a width of 200 feet, with vertical sides, which would materially lessen the cost.

Herewith submitted are eight sheets of maps comprehending—

One general map of St. Mary's River, showing the route at present used and also the new one proposed.

Four sheets of special maps, showing the soundings and topography of each of the four sections.

Two sheets of maps on a smaller scale, showing the lines of the proposed channel connectedly.

One sheet of profiles and levels.

Respectfully submitted.

H. A. ULLFERS,
Assistant Engineer.

General G. WEITZEL,
Major Corps of Engineers, U. S. A.

It would be a great benefit to commerce if this improvement could be made. The channel at present navigated can only be used in day-time, and is very dangerous in places. Frequently many hours are lost by vessels carrying passengers and valuable cargoes, and thus causing great loss. Besides, if this channel could be improved, it could be lighted and buoyed in a proper manner, as it lies entirely within our territory, and besides, it is eleven miles shorter.

But, as the cost of improvement is so great, I respectfully recommend a further survey of other channels, to ascertain if a cheaper and more feasible one cannot be obtained.

The drawings to accompany this report will be sent in a few days.

D 3.

SHEBOYGAN HARBOR, MICHIGAN.

The operations during the last fiscal year on this work have consisted in continuing the excavation across the bar. Two cuts have been completed from deep water in the lake to the river, and a third one partially begun and continued until the appropriation was exhausted.

The work already done has been of the greatest benefit, not only to the local but the general commerce of the lakes, as affording a good harbor of refuge, and a site for dry docks to repair vessels frequently damaged in this vicinity.

The appropriation of \$15,000 for this work, made by the act approve June 23, 1874, will be expended in continuing the work. Bids for this will be opened on the 15th instant.

There was no original estimate made for this work, as now contemplated. I estimated in my last annual report that it would cost \$75,000 to complete it. Of this amount, \$15,000 has been appropriated. There remains, then, \$60,000 which I recommend be appropriated at once for the sake of economy.

As above stated, this work is not only of local but of general importance. It will, when completed, be an excellent harbor of refuge, and a convenient place to erect dry-docks for the repair of damaged vessels, and will be converted into a wrecking station, I am told.

The amount that is required for the entire and permanent completion of this work is estimated at \$60,000. A detailed estimate of the cost of this work, but on a more extensive plan than is now thought necessary, was submitted by Maj. F. U. Farquhar, Corps of Engineers, in his annual report of this work for the fiscal year ending June 30, 1871. The esti-

mate amounted to \$395,000, of which amount \$55,000 has been appropriated up to date.

This work is located in the Superior collection-district, Michigan.

The nearest port of entry is Marquette, Michigan; the nearest light-house is the Sheboygan light.

The amount of revenue collected in the district during the fiscal year was \$6,235.34 coin, and \$8,201.38 currency.

The whole commerce of the great chain of lakes will be benefited by this improvement.

The amount of work done during the year was 76,955 cubic yards of excavation.

Financial statement.

Balance in Treasury of United States July 1, 1873	\$15,000 00
Amount in hands of officer and subject to his check, (including \$773.29 percentage due on contracts not yet completed)	6,984 80
Amount appropriated by act approved June 23, 1874	15,000 00
Amount expended during the fiscal year ending June 30, 1874	21,211 51
Amount available July 1, 1874	15,000 00
Amount required for the fiscal year ending June 30, 1876	60,000 00

D 4.

AU SABLE RIVER, MICHIGAN.

The operations on this work during the fiscal year have consisted in keeping the work already executed in repair, and in dredging a cut to 10 feet in depth across the bar which had formed during the spring of 1873.

The encroachments on and abuse of the channel of this river, referred to in my last annual report, and all of which tended to neutralize the work that the Government was doing, continued as reported by the agent in charge.

I therefore addressed you a letter on September 29, 1873, of which the following is a copy :

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., September 29, 1873.

GENERAL: I have the honor to inclose herewith a copy of a communication just received from my assistant on the improvement of the Au Sable River, Michigan.

There has been a great deal of trouble on this work with the lumbermen and mill-owners. I have settled all troubles relating to docks, &c., by informing them of the opinion of the Attorney-General and decisions of the Supreme Court of the United States as communicated to us by the circular from your office, dated March 10, 1873, "Riparian rights, navigable waters."

But I do not know whether rafts, being only temporary obstructions, could be brought under these decisions. They do a great deal of harm, and should come under them, but before taking action I feel that I ought to be sustained in my opinion, and I therefore respectfully beg instructions from you on this subject.

Very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

To this I received the following reply, viz :

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 3, 1873.

SIR: Your letter of September 29, in reference to obstructions in Au Sable River, has been received.

Will you please submit a sketch fully illustrating the subject, showing the localities and extent of work done by the United States under the appropriation for improve-

ment of Au Sable River, and also the localities where the obstructions are placed, and, if practicable, the amount of damage of filling up of cut caused by them?

By command of Brigadier-General HUMPHREYS.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Major of Engineers.

Maj. G. WEITZEL,
Corps of Engineers.

I therefore addressed a letter to his excellency the Governor of the State, of which the following is a copy:

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., January 26, 1874.

SIR: You are undoubtedly aware that a considerable sum of money has been expended by the General Government on the improvement of the mouth of the Au Sable River, in this State.

Since I have been in charge of the work there has been a great deal of complaint from different parties against each other.

All trouble relating to docks, &c., has, I believe, been settled. But in the beginning of last September I received complaints against the accumulation of rafts in the river awaiting egress into Lake Huron. My assistant also reported that these rafts, by increasing the scour of the stream, were causing the cut which we had made during the summer to fill up, and were thus neutralizing our work.

I applied for instructions on the subject, and I annex hereto a copy of the reply.

Now, would it not be well for your legislature to enact some proper law on this subject? You cannot expect the Government to expend money in improving your rivers and harbors if the work is not secured by proper laws against destruction by selfish parties.

Very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

His Excellency JOHN J. BAGLEY,
Governor of the State of Michigan.

As the legislature was in session only for a special purpose, I suppose the matter was not laid before it. At least I have heard nothing from it. In order to have a full report on this whole subject, I directed my assistant, Capt. A. N. Lee, Corps of Engineers, to make a personal examination of the matter.

The following is a copy of his report:

Report of Capt. A. N. Lee, Corps of Engineers.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., May 27, 1874.

MAJOR: I have the honor to submit the following report in reference to the river and harbor of Au Sable, Mich.:

The improvements here are similar to those made at most harbors on the lakes, and consist of parallel piers of crib-work extending from some distance into the lake. The amount expended on their construction so far is about \$35,000. The south pier is in good condition. The north pier, however, owing to the current of the river being deflected by the angle in the south pier, has settled considerably; the end crib especially is in a very bad condition.

No appropriation was recommended for the next fiscal year, but in my opinion immediate steps should be taken to preserve the works already completed as well as to prevent further damage to the river itself.

The river banks are composed generally of loose sand, which is easily undermined by the current, and falling into the river is carried down and deposited at the entrance to the harbor. The wear of the banks, caused by the current, alone would necessitate more or less dredging every year; but in addition to this an immense amount of damage has been done to the river and harbor, and is still being done by parties extending their docks, mills, and warehouses into the river without any regard to the public right to use the same, or with any care to the preservation of the river channel. It also often happens that the river for some distances very much obstructed by rafts, waiting either for a tug or until the weather may moderate sufficiently to allow them to get into the

lake. All these obstructions of narrowing of the channel must of course increase and alter the current and cause an increase to the usual deposit of sand at the mouth of the river.

Messrs. Loud & Gay, a firm doing a large lumber business here, in a letter to you, calling attention to the damage done the river by rafts, say, "We have a grain-house, warehouse, and lumber-dock that will hold two millions of lumber, to all of which it is very difficult to get vessels at present." These gentlemen are very careful not to say that their "long-timber" mill and dock are built on made foundation in the natural channel of the river, and entirely close up the south channel made by the swing of the State-road bridge.

The south channel was formerly the deeper of the two and the one most used. Their warehouse also extends nearly to the center of the stream. These gentlemen also say, "The rafting interests pertain almost entirely to non-residents of the place, many of them from other States, and Canada, and of course care nothing for the damage to the place or sacrifice of local interests. We can doubtless obtain redress in law as far as we are concerned, but have hoped the Government authorities would take the matter in hand and see that the river is made available for its legitimate purpose of navigation."

From this one would infer that Messrs. Loud & Gay were the injured parties; whereas the facts are, that they with other residents of the place have done everything in their power to prevent outsiders from having free use of the river, and as for obstructing and damaging the same I know of only one instance, to which I will presently refer, that can compare in magnitude with Messrs. Loud & Gay's obstructions at the swing-bridge.

About one mile from the mouth of the river Messrs. Smith, Kelly & Dwight and Moore & Alger, joint owners of the land formed by a bend or "ox-bow" in the river here, have cut through the narrow part of the bend, thus entirely changing the channel of the river for their own benefit, and causing an immense amount of sand to be deposited at the entrance to the harbor. This cut was not commenced by dredging and carrying away the sand as the work proceeded, but a narrow ditch was dug with scrapers and the water allowed to increase the cut until now it is about 180 feet wide, 30 feet deep, and one-eighth of a mile long. The large amount of sand thus carried away by the current was of course, for at least a large part of it, deposited at the mouth of the river, and I have no doubt that the greater part of the bar which the United States removed last summer was composed entirely of this material.

The owners of the river-front seem to think that they have absolute right to do what they please, not only with their frontage, but with the river itself, and wherever they have had a chance to benefit themselves by driving piles, building docks, or altering the course of the stream by cuts, they have not scrupled to do so at the expense of the public, and also to the great damage of the harbor improvement. They have charged parties rafting logs down the river enormous rents for the use of their river-fronts, and have increased these rents the last few years to such an extent as almost to prevent outsiders from getting out their timber. For instance, in 1870, owners of river-fronts received \$100 per mile for the use of their shores; in 1873 they received \$1,700 per mile. This increase was not owing to an increase in the value of their land, for most of it is absolutely worthless for agricultural purposes; but the desire seems to be to throw every obstacle in the way of non-residents using the river. The owners of the river-fronts have an undoubted right to rent the same as well as construct docks and drive piles along their fronts, provided they do not interfere with the right of the public to the free use of the stream.

The following extracts from an opinion given by the Attorney-General in 1853 are inserted, as they are believed to fully cover the case:

"The navigable waters within the State of Illinois (or within any other State) are public highways, free and common by constitutional right to the use of all the citizens of the several States equally and fully as to the use of the State of Illinois, and to be guarded and protected as such by the Government of the United States for the benefit of the whole Union. This power of conservation is perfectly distinct from the right of property and the ordinary jurisdiction on the shores of navigable waters and the soil under such waters. The sovereign may grant to individuals the right of property in the soil between high and low water mark, or below the latter, notwithstanding which *jus privatum* so granted by the sovereign, there will remain a *jus publicum* of passage and repassage, with consequent power of conservation in the sovereign.

"When," says Sir Mathew Hale, 'a port is fixed through the soil and franchise or dominion thereof *prima facie* may be in the king or by derivation in a subject, yet this *jus privatum* is burdened and superinduced with a *jus publicum*, wherein nations and foreigners in peace with this kingdom are interested by reason of common commerce, trade, and intercourse, they ought to be preserved from impediments and nuisances which may hinder and annoy the access, or abode, or recess of ships and vessels and seamen, or the unloading and reloading of goods.

“Here we see distinctly the right of conservation separated from property in the soil, and also from the franchise and dominion thereof; and a grant of the latter does not authorize the erection of that whereby the grantee shall make several to himself what ought of right to be common to all the inhabitants of the country, and to foreigners in amity with it. That is to say, there is a right independent of the *jus privatum* in the soil or dominion, namely, the right of passage, which is not subject to alienation, and prevails against any adverse claim, in view of which we may further distinguish and say that usurpation of the *jus privatum* of the sovereign in ports or navigable waters is perpesture, while invasion of the *jus publicum* of navigation is a nuisance.”

“Congress unquestionably has the power to declare the obstructions of navigable waters an offense against the United States. But this remedy, as already intimated, is not exclusive. Each State has also the power to conserve the navigable waters within its jurisdiction by suitable process known to its laws. The United States may construct works for the improvement or security of a given harbor, or as a shelter for ships from storms, or in time of war, and they may interpose for the conservation of said works, or to guard against any diminution of the existing advantages of a river, lake, or sea by the usurpation of individuals, or even of a sovereign State of the Union. But so also in my judgment may that State itself.”

From the above it appears that both the United States and the State of Michigan have undoubted right to interfere and prevent further encroachments upon the river-channel, and unless one or the other take early steps for the accomplishment of this, the river itself as well as the harbor will become perfectly useless to all but a few individuals or firms owning the river-fronts near the mouth. As an act of justice to the public at large, these parties, in my opinion, should be compelled to remove the obstructions they have placed in the river and prevented in future from obstructing in any way the same.

In a letter to the Governor of Michigan, dated January 26, 1874, you call his attention to this subject, but as the legislature was then in session for a special purpose only, nothing could be done in the matter. The next legislature does not meet until next January, and in the mean time much additional damage may be done.

In connection with the improvement of the river, I beg leave to call your attention to a plan already proposed and which you mention in your last annual report, in the opening of an artificial channel from the river to Tawas (sometimes called Ottawa) Lake or to Tawas Bay.

Much can be said in favor of this plan, and although I would not recommend any appropriation for the work itself, I think a small sum appropriated for a survey of the country between the Au Sable and Tawas Bay would be money well spent.

Some have proposed to cut a canal as a relief to the river, but I think this would be too expensive and not at all necessary. An ordinary flume of 8 or 10 feet in width by as many in depth would be ample for all the logs that would be cut in the river by non-residents of Au Sable, and as the flume would only be used for “running” logs and the rafts made up in Tawas Bay, all the difficulty now arising from blocking up the Au Sable by logs and rafts would be avoided. As things are now on the river it would be impossible for the owners of pine lands to get out as much timber as they would if they had free access to some sheltered place where they could make up their rafts.

The Au Sable is too small to raft the large amount of logs that is annually cut upon its banks, and the consequence is that a great many have to lie over for a year, and what do go down block up the river to such an extent as to seriously interfere with business as well as to injure the stream and harbor.

In 1870, 56,000,000 feet were put in the river, and of this only 11,000,000 sawed at Au Sable. In 1871, 45,000,000 feet were put in and only 8,000,000 sawed. The balance in both cases, or at least as much as it was possible to get out, was rafted away by non-residents.

The proposed relief of the river would increase greatly the amount of timber rafted by outsiders, while it would have no effect on the amount sawed at Au Sable, as the mills there have facilities, such as “boom-cuts” and mill-ponds, which enable them to have always on hand as many logs as they can use.

I inclose a tracing showing the lower part of the river Tawas, or Ottawa Lake, and Tawas Bay. The flume proposed could enter Ottawa Lake at some point as A, or be led directly to Tawas Bay. The point at which it would leave the river could only be determined after an accurate survey of the country, but from what I could learn of the nature of the ground it would probably be near the bend marked B. I have no doubt that if the United States were to authorize a survey to be made of the best route for a flume to be located, the lumbermen interested in the matter would build the same, and, aside from affording them desired facilities for getting out their logs, I think they would find it a profitable investment, as enough tolls could be taken in a few years to more than pay for the construction of the work.

I would also call your attention to the fact that for some weeks in the spring after

the ice breaks up the Au Sable is too high for rafting. During this time the proposed flume could be used to a great advantage, and would prove a benefit to the river.

Very respectfully, your obedient servant,

A. N. LEE,

Captain of Engineers, U. S. A.

Maj. G. WEITZEL,

Corps of Engineers, U. S. A.

The act of Congress approved June 23, 1874, made an appropriation from the unexpended balances pertaining to this work, of \$1,000 for a re-survey of the river and for establishing dock-lines, but gives no authority for a survey of the proposed route for a flume from the river to Tawas Bay. I respectfully recommend that an appropriation of \$2,000 be made for this survey. When this is done and the above-mentioned authorized survey is completed, I will probably be able to form some intelligent opinion on this subject, and make recommendations for the further prosecution of the work. For the present I only recommend that the sum of \$1,500 be appropriated to keep existing works in repair.

The material expended during the year in repairs was :

75 pounds wrought spikes.
27 pounds nails.
477 pounds iron drift-bolts.
3,156 feet, board-measure, timber and lumber.
16 cords stone.

The amount of work done was 19,020 cubic yards of excavation.

The amount of money required for the entire and permanent completion of this work cannot now be stated.

The amount that should be appropriated, and that can be profitably expended during the next fiscal year, is \$3,500. Of this amount \$2,000 is for the survey from the river to Tawas Lake, and \$1,500 for keeping existing works in repair.

The detailed statement of the original estimated cost of this work can be found upon the records. Eighty-five thousand dollars in round numbers has been appropriated for the work up to date.

It is situated in the Huron collection district, Michigan, about fourteen miles north of Tawas light-house. The nearest port of entry is Port Huron, Michigan.

The amount of revenue collected during the year in this district was \$84,506.99, coin, and \$22,362.34, currency.

The great interest that requires this here is the lumbering interest. The logs out and lumber manufactured here goes to all parts of this country and to Canada, and in this sense it is a work of national and international importance. If completed, it will also make a harbor of refuge on a dangerous coast.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$4,980 50
Amount in hands of officer and subject to his check.....	5,039 40
Amount expended during the fiscal year ending June 30, 1874.....	6,842 25
Amount available July 1, 1874.....	3,177 65

D 5.

IMPROVEMENT OF SAGINAW RIVER, MICHIGAN.

I was informed by letter from your office, dated June 30, 1874, that \$15,000 had been appropriated by the act approved June 23, 1874, for continuing the improvement of the Saginaw River. A project for the expenditure of this money was submitted and approved, and bids for the work will be opened on the 15th instant.

The detailed statement of the original estimated cost is as follows, viz:

5,240 piles, \$4	\$20,960 00
8,733 cubic yards dredging in connection therewith, 25 cents	2,183 25
58,000 cubic yards dredging in channel, 25 cents	14,500 00
Contingencies	3,856 75
	41,500 00

The cost of the work that may and probably will be required at other portions of the river below is as follows:

52,000 cubic yards dredging, 25 cents	\$13,000
Contingencies	1,500
	14,500

The total cost of the whole improvement will therefore be \$56,000.

I respectfully recommend that the balance required—\$41,000—be appropriated at once. Unless this is done, the work necessarily will cost more than the estimate.

This work is situated in the Huron collection district, Michigan.

This work is situated at the Saginaw River light-house. The nearest port of entry is Port Huron, Michigan.

The amount of revenue collected during the year was \$84,506.89 coin, and \$22,362.34, currency.

The chief interest that requires this improvement is the lumbering and salt interest.

The export trade from this river is very large, and extends to all parts of this country as well as Canada. I was informed that the export trade of this river in 1872 amounted to over \$13,000,000.

Financial statement.

Balance in Treasury of United States July 1, 1873	\$292 89
Amount appropriated by act approved June 23, 1874	15,000 00
Amount available July 1, 1874	15,292 89
Amount required for the fiscal year ending June 30, 1876	45,000 00

D 6.

SURVEY OF THE SAGINAW RIVER, IN THE VICINITY OF EAST SAGINAW, MICHIGAN.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., January 24, 1874.

GENERAL: I have the honor to submit the following report on the survey of the Saginaw River, in the vicinity of East Saginaw, Mich.

On the 20th of September, 1873, I received the Department letter of the 15th of the same month. I was directed by this letter to make such personal examination of the obstructed portions of the Saginaw River below East Saginaw as would enable me to report what would be the probable cost of an examination or survey necessary for the preparation of a plan and estimate of cost of improvement.

Accordingly I proceeded to East Saginaw on the 22d of September, 1873, and, in company with a number of the leading citizens of the vicinity, viewed the obstructions which were complained of.

I was offered all the assistance necessary to make the survey, and hence, on the following day, wrote to you, recommending it, and fixing its probable cost at five hundred dollars, (\$500.)

Accordingly you directed me, by letter dated October 2, 1873, to proceed with its prosecution at as early a period as practicable.

I therefore detailed Mr. Henry Gillman, assistant engineer, to take immediate charge of it, and he proceeded to do so on the 8th of October, 1873.

A copy of his report is hereto annexed, and forms a part of this report.

A map of the locality is sent to-day by express.

The obstructions complained of are all situated within a distance of 7½ miles below the Flint and Pere Marquette Railroad bridge. The main obstruction is the Carrollton Bar, about one mile below this bridge; the other obstructions being minor bars lower down, which it is believed can be removed by dredging after the improvement at Carrollton Bar is made.

This improvement consists in confining the water at this point of the river by means of a double row of piling, to be driven near the eastern shore of the river. This method of improvement was suggested by me, and I believe that the survey has shown its correctness.

The cost of the work will probably be as follows:

CARROLLTON BAR.

5,240 piles, at \$4	\$20, 960 00
8,733 cubic yards dredging in connection therewith, at 25 cents per cubic yard	2, 183 25
58,000 cubic yards dredging in channel, at 25 cents per cubic yard	14, 500 00
	37, 643 25
Contingencies	3, 856 75
Total	41, 500 00

The cost of the work that may and probably will be required at other portions of the river below is as follows:

52,000 cubic yards dredging, at 25 cents per cubic yard	\$13, 000 00
Contingencies	1, 500 00
Total	14, 500 00

The total cost of the whole improvement will therefore be \$56,000.

I respectfully recommend that this whole sum be appropriated for this purpose. It is insignificant when compared with the great amount of commerce which will be benefited thereby. I was informed that the export trade of the river in 1872 amounted to over \$13,000,000. The statistics of this commerce were promised me, but have not been received. I have been informed that they have been sent direct to Congress.

I indorse everything that Mr. Gillman says with regard to Wicke's and McLane's docks, and the dumping of dredged sand in the river; and I respectfully urge upon Congress such legislation as will enable officers in charge of river improvements to prevent parties from injuring or obstructing the navigable and improved channels, entirely to subserve their own interest to the detriment of the general good.

I am, general, very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Report of Mr. Henry Gillman, Assistant Engineer.

EAST SAGINAW, MICH., November 7, 1873.

SIR: I have the honor to report the completion of the survey and examination of the Saginaw River, ordered at this place.

The survey extends from the railroad bridge to about $7\frac{1}{4}$ miles below East Saginaw, including the towns of Carrollton and Zilwaukee and Burr's Mill; and the shore-line on both sides of the river, the docks and other features of the ground, have all been carefully located, as well as the islands, bayous, &c., while soundings have been taken throughout the entire extent.

The great impediment to the navigation of this part of the river is the Carrollton Bar, which of late years has been growing more troublesome, owing to the deposits of sand drifted from the dredgings, &c., of the upper part of the river. The location of Wicke's and McLane's docks have, no doubt, exerted an injurious influence in this direction. The river, also, immediately widens here, and at the times of the spring freshet, when the current has a velocity of three miles per hour, it overflows the low bank on the eastward into the adjacent marsh, and the effect of the scouring action is lost.

To remedy this, I would respectfully propose that the large body of water thus distributed and wasted be utilized, by being confined to the channel by a double row of pile-work, to be driven from Wicke's dock along the easterly shore of the river, and conforming as much as possible to the general direction of the shore, to a point opposite the north end of Webster's dock. The piles to be well and closely driven, and strengthened by timbers securely bolted at the top. The piles should reach above high-water mark. A certain amount of dredging would be required in connection with driving the piles, and it is advisable that some dredging should also be done in the channel to perfect the work; but there seems to be little doubt that the first spring freshet, confined to the river-bed in the manner proposed, would sweep away the entire obstruction complained of, and make a permanent channel of sufficient depth throughout.

An examination of the river shows that wherever the river is most narrow, even though tortuous, the channel is deepest. This is well exhibited in the vicinity of Zilwaukee, the narrowest part of the river and the most winding, the water there being of a greater depth than anywhere else.

Except at the time of the spring freshet the current is extremely sluggish, the velocity at most being about one-half mile per hour. During northerly winds the current frequently runs up stream. The spring freshet raises the water generally from 6 to $7\frac{1}{4}$ feet above the mean water-level, often submerging the docks of East Saginaw. The rise is usually gradual, its maximum height being attained in from two to three weeks; the flood lasts, varied with slight fluctuations, from three to four weeks, at the end of which time the river subsides to the mean level, which, during the remainder of the year, is only affected by the disturbing influences common to most rivers. There are no difficulties to be encountered in dredging, the bottom consisting of fine sand overlying a bluish clay.

There has been a large amount of dredging done in the river, about \$80,000 raised by local taxation having already been expended for the purpose, but it has been an intermittent work and has not been protected by piling. In consequence the result has been unsatisfactory. Government hitherto has given no aid here. As to the importance of the work it is unnecessary for me to speak, as you are already informed on the subject. The export trade of Saginaw River alone, in 1872, amounted to \$13,141,224. A large portion of this was with foreign countries.

As statistics embracing the value of the productions and commerce of this place are being collected, to be duly forwarded to you by the persons interested in this improvement, further reference to this subject on my part would be superfluous.

As the bed of the river is constantly changing, the sand being continually brought down and deposited on the bar and in its vicinity, (the greatest change, however, occurring during the spring freshet,) any estimate as to the amount of dredging required must, consequently, be merely approximate.

The length of the proposed pile-work is 3,930 feet, containing an aggregate of 5,240 piles. The cost of piles, including driving, bracing, and belting, at \$4 each.....	\$20,960 00
Dredging, in connection with pile-driving, 3,930 feet by 20 feet, at an average depth of 3 feet—8,733 cubic yards, at 25 cents per cubic yard.....	2,183 25
To dredge a channel 100 feet wide by 12 feet deep, outside the line of piles, at present condition of bottom—58,000 cubic yards, at 25 cents per cubic yard.....	14,500 00

Being a total, for pile-work and dredging at Carrollton Bar, of	37,643 25
Additional dredging in other parts of river, if considered advisable at this time—52,000 cubic yards, at 25 cents per cubic yard	13,000 00

Being a grand total of.....	50,643 25.
-----------------------------	------------

Though I have included "an estimate for dredging in other parts of the river," I would respectfully submit that the result of the improvement proposed at the Carrollton Bar be awaited before this be undertaken.

In this connection I would call attention to the advisability of more care being taken as to location of docks in the river. This is a matter of serious importance, and should be judiciously controlled. The dumping of dredged sand into the river should also be more thoroughly proceeded against, so as to put a stop to the practice altogether.

The points throughout the survey have been made as permanent as possible and marked for future reference.

A water-gauge was also established, and read and recorded during the taking of the soundings, being referred to a bench-mark, the corner of the stone water-table of the Commercial block, on Genesee street, near the bridge, East Saginaw, so that comparison can be made with any future examinations and surveys.

I have the honor to be, sir, very respectfully, your obedient servant,

HENRY GILLMAN,
Assistant Engineer.

General G. WRITZEL,
Corps of Engineers, U. S. A.

D 7.

HARBOR OF REFUGE, LAKE HURON.

The commencement and progress of this work is fully stated in the report of Capt. A. N. Lee, Corps of Engineers, who is my special assistant on this work, of which the following is a copy, viz:

Report of Capt. A. N. Lee, Corps of Engineers.

UNITED STATES ENGINEER OFFICE,
Detroit, August 4, 1874.

MAJOR: I have the honor to submit the following report on the construction of the breakwater for a harbor of refuge at Sand Beach, Lake Huron:

The contract for the construction of a portion of the work, under the appropriation of \$275,000, was awarded to Messrs. Dale and Davidson, of Chicago, in June, 1873.

They commenced work as soon as possible on the construction of a dock which was intended for a shelter for their machinery, tug, or as well as a place from which they could frame and launch the cribs. The heavy wind-storms of last fall washed away a large portion of the dock, and also wrecked their tug and a machine they had provided for picking up the boulder stone-filling for the breakwater from the bottom of the lake. Owing to these accidents, the many preparations the contractors have found necessary for the successful prosecution of such an extensive work, and the financial panic that crippled their means and otherwise embarrassed them, the work is only well started, with a good prospect of rapid advancement.

Four cribs have already been settled into position on the line of proposed breakwater. The angle-crib which was settled in two parts is in about 22 feet of water.

The plan suggested by Major Houston, Corps of Engineers, of dropping small boulder-stones through the grillage-bottom in sufficient quantities to form a comparatively level bed for the crib to rest upon, has been tried and with great success. The bottom on which the second crib rests was found to be very uneven, and as it is almost entirely rock, it was impossible to level it without much extra work. The crib was actually placed into position, however, and while the higher end was allowed to rest in its place on the bottom, the lower was raised by means of the clam-shell dredge, and boulder-stones, small enough to fall through the grillage, were thrown into the proper pockets until the crib rests on them. The result was better than expected, for the crib is perfectly aligned, and, so far, has shown no tendency whatever to settle.

The bottom generally is so hard that, I think, the superstructure could with safety be put on almost immediately after sinking the cribs; but, in order to be on the safe side and thoroughly test the matter, I have given my assistants directions to let each crib stand thirty days before commencing work on the superstructure. If hereafter we find that the bottom is sufficiently hard to prevent any settling, the superstructure can be added whenever convenient.

The contractors are in hopes of being able to put down a crib for each week until

the heavy weather sets in; but I am of the opinion that this is too large an estimate, as they will be more or less delayed in getting a sufficient quantity of boulder stone. Those used so far have been of all sizes, from the size of a man's fist to 15 or 16 tons weight, and have been picked from the bottom of the lake by the clam-shell dredge before mentioned. The bottom in the vicinity of the work is covered with these boulders, and I have no doubt but that a sufficient quantity could be gathered there to complete the breakwater. But it is slow work raising them, even with the good machinery the contractors have, and it will be apt to delay them more or less.

The stones are loaded on scows, by the dredge of the scows towed to the breakwater, where the stones are put in place by hand.

My assistant, Mr. R. J. Cram, says in his report, "In filling the cribs care is taken to have the stones dropped as nearly as possible in the centre of each pocket. I have recently made an examination, the result of which has led me to adopt the accompanying sketch as correctly illustrating the bridging of the stone filling between the open timber cross-walls.

If the work stands, and I have no doubt it will, until the breakwater is entirely completed, I am satisfied that neither ice nor the heavy sea to which it will be exposed can ever make a breach through the wall so long as the timber remains in good condition. After the superstructure has rotted to such an extent that its removal is necessary, the foundation will be found amply strong to support a stone superstructure.

I am satisfied from a few winters' experience on the Straits of Mackinac, St. Mary's River, and St. Clair Flats that the, only damage to this work after its entire completion, that can be done by the ice drifting about the lake, must, of necessity, be abrasion, ample protection against which is afforded by the iron-plating bolted to the face of the breakwater, along the line most likely to receive damage. The prevailing idea that breaches will be made in the breakwater by heavy fields of ice drifting before strong winds, I deem erroneous, because of the season of the year when these flows are drifting about the lakes; the bay within the breakwater will be covered with a thick and strong sheet of ice, the accumulation of a long series of severe frosts forming a natural brace, as it were, from the shore to the line along the breakwater, to receive the greatest strain from a drifting field. There may be some danger of the superstructure being crowded in the lake by the expansion of this ice that is here to cover the bay within the breakwater. Examples of this force may be seen in the wood-docks off the mouth of the Cheboygan River, which have stood for nearly twelve years, and sustained no damage from ice other than that caused by the expansion between them and the shore. The line of cribs that you propose to locate within the harbor to form berths for vessels, will, of course, lessen, if they do not altogether remove, the danger caused by the expansion of the ice."

Mr. Cram also recommended the expenditure of the appropriation of \$75,000 made at the last session of Congress for this work in extending the breakwater along the line from the angle toward the shore at least to 13 feet of water, but I am not prepared to approve this recommendation until it is seen how much of a shelter will be afforded by the completion of the work now under contract.

I have already submitted to you my estimate of the amount necessary to be appropriated for the fiscal year ending June 30, 1874.

Very respectfully, your obedient servant,

A. N. LEE,

Captain of Engineers, U. S. A.

Major G. WEITZEL, *Corps of Engineers, U. S. A.*

The work thus far constructed is good and the progress has been as good as the circumstances permitted. The appearance of the work indicates that this structure will be a success. The danger to the superstructure hinted at by Mr. R. J. Cram, inspector on the work, can easily be avoided by causing the custodian of the work at the proper time to make a cut through the ice parallel to the breakwater.

It has been suggested to me, and the suggestion strikes me as a good one, to substitute for mooring-rings recommended by the board of engineers, a line of small piers about a thousand feet inside of and parallel to the breakwater, provided with suitable snubbing-posts, to which vessels using the harbor may make fast.

By the act approved June 23, 1874, an appropriation of \$75,000 was made to continue this work. Bids for this will be opened on the 15th instant.

I am gratified at the good prospects for this work. It is one of great magnitude, and of the greatest importance to the whole commerce of

the lakes of the North and Northwest, in affording a place of shelter on this very dangerous coast, and which is entirely devoid of harbors, during the severe storms which so often prevail on Lake Huron.

The original estimate for the work made by the board of engineers in their report dated October 12, 1872, is \$1,452,550. Of this amount \$350,000 have been appropriated up to date.

The amount that can profitably be expended on it during the next fiscal year is \$200,000.

This work is situated in the collection-district of Huron, Michigan, about fifteen miles south of the Point Aux Barques light-house. The nearest port of entry is Port Huron.

The amount of revenue collected in this district during the year was \$84,506.99 coin, and \$22,362.34 currency.

As above stated, the whole commerce of the great chain of northern and northwestern lakes will be benefited by this work.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$242,800 00
Amount in hands of officer and subject to his check	15,825 02
Amount appropriated by act approved June 23, 1874	75,000 00
Amount expended during the fiscal year ending June 30, 1874.....	33,716 26
Amount available July 1, 1874.....	299,908 76
Amount required for the fiscal year ending June 30, 1876	200,000 00

D 8.

SAINT CLAIR FLATS SHIP-CANAL, MICHIGAN.

The operations on this work are fully set forth in the accompanying report of my assistant, Capt. A. N. Lee, Corps of Engineers, who, in addition to his other duties, was assigned by me as especially in charge thereof.

I will cause the rotting of the timber reported to me by Captain Lee to be carefully observed. I think, from specimens of rotten pieces that I have seen, that there is no doubt but that the gains should have been cut before creosoting the timber.

Captain Lee's report reads as follows :

Report of Capt. A. N. Lee, Corps of Engineers.

UNITED STATES ENGINEER OFFICE,
Detroit, August 4, 1874.

MAJOR: I have the honor to submit the following report of operations at St. Clair Flats Ship-Canal during the last fiscal year :

DREDGING.

Work under the present contract was commenced in June, 1873, and has progressed steadily during the favorable months which have since intervened. It is thought that in about ten days, with good weather, the work will be entirely completed.

The whole amount of material which has been removed during the year is 194,657 cubic yards.

No appropriation will be necessary for the next fiscal year, the balance remaining on hand being sufficient to pay the custodian and keep the canal in repair.

REPAIRING EMBANKMENTS.

This work has been carried on in the same manner as last year; that is, the material has been removed from the embankments in the places where leaks have occurred

and its place supplied with several layers of marsh soda, and on top of them material dredged from the bottom of the canal has been firmly packed. The plan has worked admirably so far, and it is hoped, on the completion of the work, that no further trouble will be experienced from leakage; 5,035 cubic yards of soda and 16,504 cubic yards of material dredged have been used. This last quantity is included in the amount given as dredged above. In a recent inspection of the canal, I noticed that the timbers in some places in the embankment were badly rotted. The custodian of the canal subsequently, by my orders, made another and very thorough inspection, and reports that he finds in almost every case where the gains have been cut before creosoting, the timbers are in a good state of preservation. On the contrary, where the timbers were creosoted before cutting the gains, they were badly rotted, the rots always taking place at the joints or gains. It would seem from this that the timbers were not thoroughly impregnated, and an examination of the specimens I have had taken from the canal, and submit herewith, will sustain the view, as the oil does not appear to have penetrated more than an inch at the farthest, so that when the gains are cut after creosoting, the impregnated parts are, to a great extent, cut away, and the timbers kept practically as before the process.

Very respectfully, your obedient servant,

A. N. LEE,
Captain of Engineers, U. S. A.

Maj. G. WRITZEL,
Corps of Engineers, U. S. A.

The original estimate for the work just completed was \$80,000; that is, 200,000 cubic yards dredging, at 40 cents, \$80,000. It has been done for less than the estimate.

No additional appropriation is required for this work.

It is located in the collection-district of Detroit, Mich. The nearest port of entry is Detroit, Mich.

The amount of revenue collected at this port during the year was \$232,340.98, in coin. The whole commerce of the great chain of northern and northwestern lakes is benefited very much by this work.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$160,000 00
Amount in hands of officer and subject to his check.....	547 19
Amount expended during the fiscal year ending June 30, 1874	45,153 53
Amount available July 1, 1874.....	55,393 66

D 9.

IMPROVEMENT OF THE SAINT CLAIR RIVER AT THE MOUTH OF BLACK RIVER, MICHIGAN.

Operations on this work were continued until the funds appropriated were exhausted. This occurred on the 4th of November, 1873. The operations consisted in dredging the material from the bar at the mouth of Black River to a depth of 13 feet, and making a cut of 100 feet wide and 15 feet deep through the middle ground, the inside edge of this cut being 25 feet from the docks.

All the material dredged consisted of coarse sand and gravel, and was dumped in deep water below the bar.

The appropriation of \$15,000 made for this work by the act approved June 23, 1874, will be expended in continuing the 15-foot cut, as there are many vessels drawing over 13 feet that will then be enabled to pass up and down on the American side of the river. The amount of work done during the year was 53,074 cubic yards dredging.

The detailed estimate originally made for this work amounted to

\$224,444. (See annual Report Chief of Engineers for 1872, page 177.) Of this amount \$45,000 has been appropriated up to date.

The amount that is required for the entire and permanent completion of the work is \$179,244.

The amount that can be profitably expended during the next fiscal year is \$15,000.

It is situated in the collection-district of Huron, Mich.

The nearest port of entry is Port Huron, and the nearest light-house is at Fort Gratiot, Mich.

The amount of revenue collected in this district during the year, was \$84,506.99, coin, and \$22,362.34, currency.

The whole commerce of the northern and northwestern lakes passes here and would be benefited by this improvement.

Financial statement.

Balance in Treasury of United States July 1, 1873, ...	\$15, 000 00
Amount in hands of officer and subject to his check (including \$1,377.95 percentage due on contracts not yet completed)	1, 377 95
Amount appropriated by act approved June 23, 1874	15, 000 00
Amount expended during the fiscal year ending June 30, 1874	15, 000 00
Amount available July 1, 1874	15, 000 00
Amount required for the fiscal year ending June 30, 1876	15, 000 00

D 10.

CHANNEL CONNECTING LAKES HURON AND ERIE.

DETROIT, MICH., *January 12, 1874.*

GENERAL: In accordance with the instructions contained in your letter of the 23d ult., and the resolution of the House of Representatives, of which a copy was inclosed, we have the honor to report as follows:

In order to obtain a depth of water of twenty feet in the channel which connects Lakes Huron and Erie, excavations must be made at four different points:

- 1st. Saint Clair Flats ship-canal.
- 2d. Lake Saint Clair.
- 3d. Detroit River, at the lime-kilns.
- 4th. At the mouth of the Detroit River.

In the Saint Clair Flats ship-canal it will be impossible, without the greatest danger to the existing dikes which inclose it, to give such a channel a greater width than one hundred feet; and therefore this has been taken as the greatest allowable width.

Through Lake Saint Clair the channel has been taken at four hundred feet in width, on account of the high winds which sometimes prevail there, and also its great length.

At the lime-kilns on the Detroit River an excavation must be made through rock, undoubtedly overlaid at some places by bowlders. But the information on this point at our command is not complete, and therefore we have assumed it in our estimates as solid rock throughout.

Notwithstanding the great expense of making the cut at this point, we have taken the least allowable width of the channel at three hundred feet, on account of the great damage to which a large vessel would be exposed in striking the sides of a narrower rock-cut.

At the mouth of the Detroit River, the cut to be made is through sand and mud. Here we have assumed the least allowable width of the

channel at four hundred feet. The reasons for this, and with stronger force, are the same as those given for the channel through Lake Saint Clair.

We assume the cost of the excavation in the Saint Clair Flats ship-canal at twenty-five cents per cubic yard. Experience at this point has shown this to be a fair estimate.

For the cut across Lake Saint Clair, we have assumed the cost at thirty-five cents per cubic yard, on account of the delay that would be caused to the work by winds.

At the lime-kilns, thirty dollars per cubic yard is not considered too high, on account of the depth of water, (about eighteen feet,) and the swiftness of the current.

At the mouth of Detroit River, the cost of the work is assumed at fifty cents per cubic yard, on account of winds and seas.

Assuming these prices to be correct, the cost of the work will be \$2,790,907, as shown in detail by the estimate hereto annexed.

In this connection, it should be stated that not more than fourteen feet of water can be carried into a majority of the lake harbors at the ordinary stage of water, and, therefore, in order that the full depth of a twenty-foot channel may be useful, the lake harbors would need the corresponding deepening.

In making the estimate for the work at the lime-kilns, the channel was located in the best position. This brings it partly in Canadian waters. If this is considered an objection, it can be thrown wholly into American waters, but its cost would be increased sixty per cent. thereby, making total cost \$3,930,901.

Very respectfully, your obedient servants,

C. B. COMSTOCK,

Major of Engineers and Bvt. Brig. Gen.

G. WEITZEL,

Major of Engineers and Bvt. Maj. Gen.

Brig. Gen. A. A. HUMPHREYS,

Chief of Engineers, U. S. A.

ESTIMATE.

Ship-canal at St. Clair Flats.

Dredged cut, 7,775 feet long—116,928 cubic yards, at 25 cents.....	\$29,232
--	----------

Lake St. Clair.

Dredged cut, 25,000 feet long—673,800 cubic yards, at 35 cents.....	235,830
Dredged cut, 33,000 feet long—761,652 cubic yards, at 35 cents.....	266,578

Lime-kilns.

Rock-cut, in 18 feet of water, 2,100 feet long—63,333 cubic yards, at \$30....	1,899,990
--	-----------

Mouth of Detroit River.

Dredging, at intervals for 15,000 feet—211,116 cubic yards, at 50 cents	105,558
---	---------

Add 10 per cent for contingencies.....	2,537,188
	253,719

Total	2,790,907
Add 60 per cent., if rock-cut at lime-kilns is wholly in American waters....	1,139,994

Making total cost.....	3,930,901
------------------------	-----------

APPENDIX E.

ANNUAL REPORT OF MAJOR FRANKLIN HARWOOD, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1874.

BALTIMORE, MD., *October 2, 1874.*

GENERAL: I have the honor to submit herewith my annual reports for the works of river and harbor improvement under my charge for the fiscal year ending June 30, 1874, at which date Lieut. Col. C. E. Blunt, Corps of Engineers, relieved me of their charge. I am consequently indebted to that officer for all statistics relating to progress of work beyond date of my relief. The delay in submitting these reports was unavoidable, and due to the time necessarily consumed in referring to the records of the Buffalo office, and my constant absence on duty under my present detail.

I am, general, very respectfully, your obedient servant,

F. HARWOOD,

Major of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

E 1.

IMPROVEMENT OF MONROE HARBOR, MICHIGAN.

Under contract with J. M. Sterling, of Monroe, Mich., the piers of entrance, which had fallen into a ruinous condition, were thoroughly repaired. The projected renewal of revetment of the canals was commenced by protecting the head of each canal, where the abrasion was the worst, by piling and sheathing. One thousand one hundred and sixty running feet of this work in all was constructed. The entire length of each canal on both banks needs a like protection, but more especially near the mouth of the harbor. Slight annual dredging may be needed to preserve the depth of channel at the mouth of the harbor.

The appropriation of \$10,000, made by act of June 23, 1874, will be expended in renewing the canal revetment at the most important points.

Amount required for entire and permanent completion of the project.....	\$40,000
Amount that can be profitably expended during the next fiscal year.....	40,000

Monroe Harbor, Mich., is in the collection-district of Detroit, Mich., and has a light at end of north pier, at entrance of Raisin River.

Amount of revenue collected and number of entrances and clearances have been found impracticable to obtain, as they are included in the Detroit district.

ABSTRACT OF CONTRACTS.

Contract with J. M. Sterling, of Monroe, Mich., for furnishing labor and material, excepting iron, for repairs to piers, dated June 18, 1873, expired June 30, 1874.

Contract with Cartwright, McCurdy & Co., of Cleveland, Ohio, dated June 18, 1873, for supplying iron, expired November 30, 1873.

*Abstract of contracts for each class of material and labor.***J. M. Sterling :**

1. Pine timber and lumber, M feet, board-measure.....	\$19 75
2. Oak timber and lumber, M feet, board-measure	24 00
3. Oak piles driven in place, lineal foot.....	27
4. Framing, &c., below water work, lineal foot.....	10
5. Framing superstructure, lineal foot.....	09
6. Fitting, &c., planks and joists, &c., M feet, board-measure.....	7 00
7. Stone in the work, cord.....	8 00
8. Brush in place, cord.....	7 00

Cartwright, McCurdy & Co. :

1. Nut screw and washer bolts, pound.....	7. 65
2. Drift-bolts, pound.....	3. 65
3. Spikes, pound	5.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$10,000 00
Amount in hands of officer and subject to his check, (including \$668.76 percentage due on contracts not yet completed).....	7,669 20
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	17,568 54
Amount available July 1, 1874	10,100 66
Amount required for the fiscal year ending June 30, 1876.....	40,000 00

E 2.**IMPROVEMENT OF TOLEDO HARBOR, OHIO.**

Under contract with William Richardson, of Buffalo, N. Y., during the fiscal year a channel 15 feet deep and 100 feet in width, excepting a stretch of half a mile, which is only 80 feet in width, was completed from Toledo to the lake. Further appropriations will be applied to completing the project of the board of engineer officers of December, 1872.

Amount that can be profitably expended during the next fiscal year..... \$325,000

Toledo Harbor, Ohio, is located in the collection-district of Miami, and has a light-house on Turtle Island, at entrance to Maumee Bay.

Amount of revenue collected during the fiscal year ending June 30, 1874.. \$18,792 14

Entrances and clearances during the fiscal year ending June 30, 1874..... 5,355

Tonnage

1,028,876

ABSTRACT OF CONTRACT.

Contract with William Richardson, of Buffalo, N. Y., dated June 18, 1873, expired June 30, 1874, for supplying four dredges, each with two dump-scows, and one tug, with crew, machinery, and all accessories complete, for \$115 per day, working ten hours, and \$10 per day demurrage when idle for each dredge and equipment.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$85,000 00
Amount in hands of officer and subject to his check.....	15,536 34
Amount appropriated by act approved June 23, 1874.....	75,000 00
Amount expended during the fiscal year ending June 30, 1874.....	100,017 57
Amount available July 1, 1874	75,518 77
Amount required for the fiscal year ending June 30, 1876.....	325,000 00

E 3.**IMPROVEMENT OF PORT CLINTON HARBOR, OHIO.**

The catch-sand fence referred to in my last annual report was built on the north spit, at the mouth of Portage River, to prevent its encroachment on the channel. It has answered its purpose excellently, but may possibly need extension from time to time. No further improvement can be effected short of the extensive project mentioned in the last annual report—

Port Clinton Harbor, Ohio, is in the collection-district of Sandusky, Ohio, and nearest the port.

Amount of revenue collected during the fiscal year ending June 30, 1874, \$191.91.

Entrances and clearances during the fiscal year ending June 30, 1874, 566; tonnage of same, 30,302 tons.

Financial statement.

Amount in hands of officer and subject to his check, (including \$318.54 percentage due on contracts not yet completed).....	\$4, 674. 62
Amount expended during the fiscal year ending June 30, 1874.....	4, 420. 97
Amount available July 1, 1874.....	253. 65

E 4.**IMPROVEMENT OF SANDUSKY CITY HARBOR, OHIO.**

Under contract with William Richardson, of Buffalo, N. Y., during the fiscal year a channel, averaging 75 feet in width and 15 feet deep, low stage, was effected over the shoal in the bay. So far as this shoal is concerned, access to the city wharves is readily had. A further widening to 100 feet is advisable, but useless until the outer bar at Cedar Point is surveyed and dredged, as it is now impassable to vessels drawing more than 10 feet water.

The appropriation of \$25,000 made by act of June 23, 1874, will be devoted to dredging this bar.

Amount required for entire and permanent completion of the improvement not estimated; as, in my opinion, the permanent completion cannot be effected without confining channels within canal-dikes.

Amount that can be profitably expended during the next fiscal year, \$105,000.

Sandusky City Harbor, Ohio, is located in the collection-district of Sandusky City, Ohio, near lights on Cedar Point and Marble Head.

Amount of revenue collected during the fiscal year ending June 30, 1874, \$1,640.24. Entrances and clearances during the fiscal year ending June 30, 1874, 3,328; tonnage of same, 553,447 tons.

ABSTRACT OF CONTRACT.

Contract with William Richardson, of Buffalo, N. Y., dated June 18, 1873, expired June 30, 1874. For hire of 2 dredges, 4 dump-scows, 2 tugs, with crews, machinery, and equipments complete, for \$125 per day for each dredge and equipment, working 10 hours, and \$10 per day demurrage while idle.

Financial statement.

Balance in Treasury of United States July 1, 1873	\$20, 000 00
Amount in hands of officer and subject to his check, (including \$719.61 percentage due on contracts not yet completed).....	10, 023 78
Amount appropriated by act approved June 23, 1874.....	25, 000 00
Amount expended during the fiscal year ending June 30, 1874.....	30, 006 93
Amount available July 1, 1874.....	25, 016 85
Amount required for the fiscal year ending June 30, 1876.....	105, 000 00

E 5.

IMPROVEMENT OF HURON HARBOR, OHIO.

The repairs projected in the last annual report were effected by day-labor. The harbor is now in excellent condition. It only remains to repair the piers and dredge away a shoal at the base of the west pier, most of which will be done during the present year. The sum of \$1,500 having been appropriated by act of June 23, 1874, a further appropriation of \$1,000 is asked to complete the harbor.

Amount required for entire and permanent completion of repairs, &c.....	\$1,000 00
Amount that can be profitably expended during the next fiscal year.....	1,000 00
Amount of revenue collected during the fiscal year ending June 30, 1874.....	71 26
Entrances and clearances during the fiscal year ending June 30, 1874.....	156 00
Tonnage of same 17,041 tons.	

Financial statement.

Balance in Treasury of United States July 1, 1873	\$3,300 00
Amount in hands of officer and subject to his check	3,049 21
Amount appropriated by act approved June 23, 1874.....	1,500 00
Amount expended during the fiscal year ending June 30, 1874.....	5,123 26
Amount available July 1, 1874.....	2,725 96
Amount required for the fiscal year ending June 30, 1876.....	1,000 00

E 6.

IMPROVEMENT OF VERMILLION HARBOR, OHIO.

Under contract with O. J. Jennings of Dunkirk, N. Y., during the fiscal year, the east pier of entrance was extended 132 feet, the west 66 feet, rendering the approach to the harbor commodious. Blasting and dredging the channel were also completed, giving ready access to the interior harbor to heavy-draught vessels. The base of the east pier was also protected by connecting it with the shore by a bulkhead backed with shale. This protection needs further re-inforcement. The older portions of the pier, likewise, need repairs. To these objects further appropriations should be applied. A request is made by citizens for widening of the channel to 100 feet with 14 feet depth of water. As the commerce of this harbor is rapidly growing, this request is worthy of consideration.

Amount required for entire and permanent completion of repairs.....	\$3,000 00
Amount that can be profitably expended during the next fiscal year.....	3,000 00

Vermillion Harbor, Ohio, is located in the collection-district of Sandusky, Ohio, has a beacon-light on pier behind the west pier.

Amount of revenue collected during the fiscal year ending June 30, 1874, \$122.62.

Entrances and clearances during the fiscal year ending June 30, 1874, 252. Tonnage of same, 26,399 tons.

ABSTRACT OF CONTRACTS.

Contract with O. J. Jennings of Dunkirk, N. Y., for furnishing all labor and material excepting iron, for extension of the piers, dated June 18, 1873, expired June 30, 1874.

Items.

1. Hemlock timber and lumber, M feet, board-measure	\$18 00
2. Pine timber and lumber, M feet, board-measure	23 00
3. Framing, &c., under-water work, lineal foot	10
4. Framing &c., superstructure work, lineal foot	10
5. Fitting, &c., planks and joists, M feet, board-measure	9 00
6. Snubbing-posts in place, each	9 00
7. Stone in the work, cord	7 25

Contract with Cartwright, McCurdy & Co., of Cleveland, Ohio, for furnishing all iron-material for extension of piers, dated June 18, 1873, expired November 30, 1873.

Items.

1. Nut, screw, and washer bolts, pound	7 44 c.
2. Drift-bolts, pound	3 18 c.
3. Spikes, pound	5 c.

Financial statement.

Balance in Treasury of United States July 1, 1873	\$9,000 00
Amount in hands of officer and subject to his check, (including \$149.60 percentage due on contracts not yet completed)	5,083 83
Amount appropriated by act of June 23, 1874	3,000 00
Amount expended during the fiscal year ending June 30, 1874	14,083 83
Amount available July 1, 1874	3,000 00
Amount required for the fiscal year ending June 30, 1876	13,000 00

E 7.

ENLARGEMENT OF THE CHANNEL OF VERMILLION HARBOR, OHIO.

Report of Lieut. Col. C. E. Blunt, Corps of Engineers.

UNITED STATES ENGINEER OFFICE,
Buffalo, N. Y., September 15, 1874.

GENERAL: I have received from the Hon. C. Foster, M. C., a communication on the subject of further appropriations for the harbor of Vermillion, Ohio, in his district.

No estimate was sent in by me for this harbor for next year, as no information was in my possession showing that further improvement was needed.

I find, however, that Major Harwood, while making no specific recommendation, still speaks of the widening and deepening of Vermillion channel as probably justifiable by the increasing commerce of the place.

Mr. Foster states that the citizens are very much disappointed that no estimate has been made, and inquires if I cannot make a supplemental report. I have replied, that all I can do now is to state the case to the Engineer Department.

I estimate that to widen the channel at Vermillion to 100 feet, and deepen it to 14 feet, will require the removal of 2,000 cubic yards of rock at \$2.50, and 15,000 cubic yards of sand and gravel at 33 cents. Total, \$10,000.

This estimate, however, is only approximate, as I have no data of later date than August, 1872, since which time more work has been done.

I propose to have made immediately a new survey and map of this harbor, when I shall be able to make a more accurate estimate.

I find that drawings are also needed of several other harbors in the district, in order to bring information up to the latest dates, and I accordingly propose to have the necessary surveys made as soon as practicable.

Very respectfully, your obedient servant,

C. E. BLUNT,
Lieutenant-Colonel of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

E 8.

IMPROVEMENT OF BLACK RIVER HARBOR, OHIO.

Under contract with D. E. Bailey, of Buffalo, N. Y., the work of pier extension was continued. During the fiscal year superstructure was built and filled with stone over twelve cribs; and three cribs on the east and four on the west pier were sunk and filled with stone, but not covered with superstructure. The progress of the work was somewhat retarded, owing to the difficulty in procuring suitable timber. At the close of the season of 1873 the crib-work was decked over with 4-inch plank in order to prevent the sea from washing out the stone ballast. The latter part of the winter being open and variable, the running ice was driven by the severe storms of February and March with great force against the crib extension. The cribs withstood the shocks rigidly, scarcely working out of line, but the exposed ends of the superstructure were thrown out of line and a few courses of timbers torn out of place. Considering the character of the storms and the masses of ice hurled on this work, the damage inflicted is light. Twelve to fourteen days' labor will suffice to repair damages. The stone ballast of the cribs has worked through the loose sand and now rests on the clay strata, and more filling will be necessary.

During the season the outer bar was very satisfactorily dredged by hired labor, so that the result of the last soundings gives a depth of 14 feet water, low stage. In order to preserve the harbor and make it accessible to heaviest-draught vessels, it remains to carry out the pier extension to 15 feet water, viz, three cribs on the east and four cribs on the west pier.

Amount required for the entire and permanent completion of the improvement, \$10,000.

Amount that can be profitably expended during the next fiscal year, \$10,000.

Black River Harbor, Ohio, is located in the collection-district of Cuyahoga, Ohio. Nearest port of entry is Cleveland, Ohio, and has a lake-coast-harbor light on end of west pier. Amount of revenue collected during the fiscal year ending June 30, 1874, credited to Cleveland, Ohio.

Entrances and clearances during the fiscal year ending June 30, 1874, 202; tonnage of same 20,139 tons.

ABSTRACT OF CONTRACTS.

Contract with D. E. Bailey, of Buffalo, N. Y., for furnishing all labor and material, excepting iron, for extension of piers, dated June 18, 1873, expired June 30, 1874.

Contract with Cartwright, McCurdy & Co., of Cleveland, Ohio, for furnishing iron-material for pier extension, dated June 18, 1873, expired November 30, 1873.

Abstract of contracts for each class of material and labor.

D. E. Bailey :

1. Hemlock timber and lumber, M feet, board-measure.....	\$14 00
2. Pine timber and lumber, M feet, board-measure.....	22 00
3. Framing, &c., under water, lineal foot.....	10
4. Framing, &c., superstructure, lineal foot.....	10
5. Stone in the work, cord.....	9 00
6. Fitting, &c., planks and joists, &c., M feet, board-measure.....	8 00

Cartwright, McCurdy & Co. :

1. Nut, screw, and washer bolts, pound.....	7.88c.
2. Drift-bolts, pound.....	3.44c.
3. Spikes, pound.....	5

Financial statement.

Balance in Treasury of United States July 1, 1873	\$14,003 78
Amount in hands of officer and subject to his check, (including \$1,566.53, percentage due on contracts not yet completed).....	11,092 08
Amount appropriated by act approved June 23, 1874	20,000 00
Amount expended during the the fiscal year ending June 30, 1874.....	25,551 02
Amount available July 1, 1874.....	18,281 88
Amount required for the fiscal year ending June 30, 1876.....	10,000 00

E 9.

IMPROVEMENT OF ROCKY RIVER HARBOR, OHIO.

Under contract with Hemenway & Garfield, of Painesville, Ohio, 360 feet of piling was built, exhausting the appropriation.

By act of June 23, 1874, a further appropriation of \$10,000 was made, which amount, by the terms of the act, is to be expended in preserving and continuing the work upon the pier. A harbor can, of course, be made at this point, but only at a great expense. There are no indications of any commerce to be benefited by this improvement, and should the new breakwater proposed for Cleveland be built, there would seem to be no reason whatever for further expenditures at Rocky River. Should Congress, however, decide to continue operations, a sufficient appropriation to finish it in one season, according to the project of Major McFarland, United States Engineers, should, in my opinion, be made. I accordingly make estimate, it being understood that such estimate carries no recommendation for further appropriation, a matter which is respectfully submitted to the judgment of Congress.

Amount required for entire and permanent completion of work, \$240,000.

Amount that can be profitably expended during the next fiscal year, \$240,000.

No entrances and clearances; no revenue collected.

Rocky River Harbor is located in the collection-district of Cuyahoga, Ohio, and near Cleveland light-house.

ABSTRACT OF CONTRACT.

Contract with Hemenway and Garfield, of Painesville, Ohio, for furnishing material and labor for construction of a pier from west end of sand-beach, expired November 1, 1873.

Abstract of contract for each class of material and labor.

1. Pine and hemlock timber, M feet, board-measure	\$25 00
2. Piles, lineal foot, driven in place.....	50
3. Screw and washer bolts, pound.....	08
4. Drift-bolts, pound.....	06
5. Spikes, pound	07
6. Stone in the work, cord.....	8 00
7. Dredging sand, gravel, &c., cubic yard.....	40
8. Framing, &c., below water, lineal foot.....	11
9. Framing, &c., superstructure, lineal foot.....	10
10. Fitting, fastening, &c., planks and joist, M feet, board-measure.....	7 00

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$1,000 00
Amount in hands of officer and subject to his check.....	7,722 37
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	8,722 37
Amount available July 1, 1874.....	10,000 00
Amount required for the fiscal year ending June 30, 1876.....	240,000 00

E 10.

IMPROVEMENT OF CLEVELAND HARBOR, OHIO.

The most pressing repairs of the piers were attended to by day-labor, exhausting the appropriation. The appropriation for 1874-'75 will be needed to put the piers in good order, which can be done during the fiscal year.

Amount required for entire and permanent completion of the improvement, (including construction of proposed exterior breakwater, \$1,250,000,) \$1,254,000.

Amount that can be profitably expended during the next fiscal year, \$504,000.

Cleveland Harbor, Ohio, is located in the collection-district of Cuyahoga, Ohio; has a light-house on the mainland, east of entrance to the harbor, and a beacon on the east pier.

Amount of revenue collected during the fiscal year ending June 30, 1874, \$165,865.26, which includes revenue from Grand River and Black River Harbors and Conneaut.

Entrances and clearances during the fiscal year ending June 30, 1874, 8,226; tonnage of same, 2,659,060 tons.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$1,000
Amount appropriated by act approved June 23, 1874.....	30,500
Amount expended during the fiscal year ending June 30, 1874	1,000
Amount available July 1, 1874	30,500

E 11.

IMPROVEMENT OF GRAND RIVER HARBOR, OHIO.

Under contract with Hemenway and Garfield, of Painesville, Ohio, the pier-extension was continued until September 30, 1873. The work then stood as follows: East pier under-water work, 270 feet long, with 91 feet of incomplete superstructure over it; west pier under-water work, 570 feet long, with 300 feet of incomplete superstructure over it, the appropriation being exhausted. During the year a heavy flood made a breach at the base of the east pier, sweeping a channel out into the lake, which channel partly existed at the close of the fiscal year. It will be necessary to continue the pier at an angle backward across this channel-bed to prevent a recurrence of this action and to confine the river to its bed. Sheath-piling is also required at the base of west pier, to prevent the river breaking through on that side and attacking the pier in reverse. Those points being attended to, and the piers built up to their prescribed height and extent, the harbor will be complete.

Amount required for entire and permanent completion of the improvement...	\$15,000
Amount that can be profitably expended during the next fiscal year	15,000

Grand River Harbor, Ohio, Fairport, is situated in the collection-district of Cuyahoga, Ohio, and near Grand River light.

Amount of revenue collected during the fiscal year ending June 30, 1874, credited to Cleveland.

Entrances and clearances during the fiscal year ending June 30, 1874, 138; tonnage of same, 12,474 tons.

ABSTRACT OF CONTRACT.

Contract with Hemenway & Garfield, of Painesville, Ohio, for furnishing material and labor for extension east and west piers; dated May 16, 1872; expired November 1, 1873.

Abstract of contract for each class of material and labor.

1. Pine timber and plank, M feet, board-measure.....	\$21 95
2. Piles, lineal feet, driven in place.....	50
3. Screw and washer bolts, pound.....	8
4. Drift-bolts, pound.....	5½
5. Spikes, pound.....	6½
6. Boiler-iron plate, pound.....	10
7. Stone in the work, cord.....	8 95
8. Dredging, cubic yard.....	50
9. Framing, &c., under-water work, lineal foot.....	10
10. Framing superstructure, lineal foot.....	9
11. Fitting, &c., planks and joists, M feet, board-measure.....	6 00½

Financial statement.

Balance in Treasury of United States, July 1, 1873.....	\$13,664 59
Amount in hands of officer and subject to his check, (including \$3,437.05 percentage due on contracts not yet completed).....	9,407 19
Amount appropriated by act approved June 23, 1874.....	20,000 00
Amount expended during the fiscal year ending June 30, 1874.....	23,071 78
Amount available July 1, 1874.....	20,000 00
Amount required for the fiscal year ending June 30, 1876.....	15,000 00

E 12.

IMPROVEMENT OF ASHTABULA HARBOR, OHIO.

By contract with F. A. Seymour, of Fulton, N. Y., a channel 14 feet deep, low stage, was completed from the harbor outward to the flare of west pier. The bar at the mouth of the harbor was also dredged, making a channel through it 120 feet wide into the lake. During the winter blasting was done to complete a continuous channel from harbor to lake, which was effected by the close of the fiscal year, there being then a continuous channel 60 feet wide and 14 feet deep, low stage. To effect this, however, the dredging at the bar had to be repeated at opening of navigation in 1874, there being only from 8 to 9 feet water where 14 feet had been obtained at the close in 1873. This influx of sand is the great trouble to be combatted at Ashtabula. It is recommended to do this by extending the west pier to at least 14 feet sounding in the lake to stop the drift around its head. At the base of the pier, however, the sand sweeps under and is blown over the old work. This has been in part met by a timber barrier, but the only effective way apparently to stop it is to build a sheath-pile, catch-sand, fence along the length of pier where the difficulty occurs. The above are the measures of improvement of greatest importance, and until they are effected extensive annual dredging will be required. The growing trade of the harbor warrants that the channel having been secured it should be widened to 100 feet, as its present width, although navigable, is not convenient, vessels not being able to pass each other in it.

Amount required for entire and permanent completion of improvement.....	\$45,000
Amount that can be profitably expended during the next fiscal year.....	45,000

Ashtabula Harbor, Ohio, is in the collection-district of Cuyahoga, Ohio, and has a beacon on east pier.

Amount of revenue collected during the fiscal year ending June 30, 1874, credited to Cleveland Harbor, Ohio.

Entrances and clearances during the fiscal year ending June 30, 1874, 271; tonnage of same, 57,817 tons.

Abstract of contract for each class of labor.

Drilling, blasting, and removing solid rock, per cubic yard.....	\$2 35
Removing loose rock, per cubic yard.....	50
Removing sand, per cubic yard.....	35

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$10,000 00
Amount in hands of officer and subject to his check.....	5,997 10
Amount appropriated by act approved June 23, 1874.....	35,000 00
Amount expended during the fiscal year ending June 30, 1874.....	15,973 63
Amount available July 1, 1874.....	35,023 47
Amount required for the fiscal year ending June 30, 1876.....	45,000 00

E 13.

IMPROVEMENT OF CONNEAUT HARBOR, OHIO.

This harbor has undergone no change since my last annual report other than the settling of the west pier-head a few inches. During the working season of 1873 the appropriation was used to riprap the head of this pier to remedy this settling.

Amount required for entire and permanent completion	\$1,000
Amount that can be profitably expended during the next fiscal year	1,000

Conneaut Harbor is in the collection-district of Cuyahoga, Ohio. The nearest port of entry is Erie, Pa., and has a beacon behind east pier.

Amount of revenue collected during the fiscal year ending June 30, 1874, credited to Cleveland.

Number of entrances and clearances during the fiscal year ending June 30, 1874, 24; tonnage, 3,195.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$400 00
Amount appropriated by act approved June 23, 1874.....	1,500 00
Amount expended during the fiscal year ending June 30, 1874.....	399 55
Amount available July 1, 1874.....	1,500 45
Amount required for the fiscal year ending June 30, 1876.....	1,000 00

E 14.

IMPROVEMENT OF ERIE HARBOR, PENNSYLVANIA.

By contract with Lee and Dunbar, of Erie, Pa., dredging in the channel and at the bar at its mouth was continued until the appropriation was exhausted. Although the original channel project is not yet completed, full width not having been obtained, still, a good channel for all lake vessels exists, and necessities have arisen which demand more immediate attention. The fall and winter gales of 1873 have made alarming attacks on existing protections to the Presque Isle, and the harbor. The north pier has been badly damaged, and needs extensive repairs. The adjacent beach is threatened with a breach into Misery Bay. The lake has swept over into the bay at the westward neck of the peninsula. To meet all these attacks, there is needed, first and most important, a breakwater or beach protection, from the base of the north pier, northward to the base of the point which makes out from the peninsula eastwardly into the lake; secondly, a thorough overhauling and

repair of the north pier; and, thirdly, a complete replanting of the neck of the peninsula with willow-roots embedded at water-level, the slips heretofore planted having failed to thrive sufficiently to resist the attack of the lake. Besides this, a slight annual dredging at the mouth of the harbor is required to keep it open. Until these objects have been attended to, it is respectfully recommended to suspend widening the existing channel, and that new appropriations be applied to the above-mentioned improvements in the order stated. The piers require overhauling and refilling, for which estimate was made in my last annual report. The present commerce of the harbor demands no further improvement.

It is proposed to expend the appropriation made June 23, 1874, in protecting the beach of the north spit from abrasion, repairing the north pier, and such dredging in the channel as may be found necessary.

For widening and completing the existing channel and further securing of Presque Isle beach, additional appropriation of \$80,000 is needed.

Erie Harbor is in the collection-district of Erie, Pa.; has a light-house on the mainland, three range-lights at entrance to Presque Isle Bay, two range-lights upon the peninsula to the northwest of entrance, and a coast-light on the north shore of the peninsula.

Amount of revenue collected during the fiscal year ending June 30, 1874, \$26,923.23.

Entrances and clearances during the fiscal year ending June 30, 1874, 2,262; tonnage, 1,069,326 tons.

ABSTRACT OF CONTRACT.

Contract with Lee and Dunbar, of Erie, Pa., dated August 31, 1872, for removing sand from channel, at 29½ cents per cubic yard.

Financial statement

Balance in Treasury of United States July 1, 1873.....	\$8, 000 00
Amount in hands of officer and subject to his check, (including \$327.81 percentage due on contracts not yet completed).....	2, 320 81
Amount appropriated by act approved June 23, 1874.....	20, 000 00
Amount expended during the fiscal year ending June 30, 1874.....	10, 195 28
Amount available July 1, 1874.....	20, 125 53
Amount required for the fiscal year ending June 30, 1876.....	80, 000 00

E 15.

IMPROVEMENT OF DUNKIRK HARBOR, NEW YORK.

Under contract with O. J. Jennings, of Dunkirk, N. Y., the improvement of this harbor was continued in accordance with the project of the board of engineer officers of November 3, 1870.

At the close of the working season of 1873, the breakwater stood 360 feet complete, having at its westerly end the 180 feet of under-water work laid, necessary to bring the end to the edge of the proposed channel. During the winter, superstructure over this section was in course of construction. Blasting and dredging in the channel defined by the board was also carried on, but under great difficulties, owing to the open winter and shifting ice, which obliged work to be suspended and laid out again several times. About one-half of the necessary area of rock was blasted, of which 2,375 cubic yards was removed, and also 8,500 cubic yards of sand. At the close of the fiscal year the contract expired, and the appropriation was nearly exhausted, leaving the channel incomplete and the superstructure over the western end of the work unfinished, and

60 feet of the under-water work laid at the easterly end. In continuing the approved project, the matter of first importance is to complete the channel of 170 feet width and 13 feet depth, which can be readily done in one season, and the unfinished superstructure completed as well. Dunkirk will then have an excellent harbor, becoming more and more inclosed, and covered year by year, as the breakwater is extended.

Amount required for entire and permanent completion of project..... \$100,000
Amount that can be profitably expended during the next fiscal year..... 100,000

Dunkirk is located in the collection-district of Dunkirk, N. Y., has a light-house on the mainland, a beacon at the end of the west pier, and a day-beacon on the opposite side of the channel.

Amount of revenue collected during the fiscal year ending June 30, 1874, \$136.85.

Entrances and clearances during the fiscal year ending June 30, 1874, 84; tonnage of same, 29,130 tons.

ABSTRACT OF CONTRACTS.

Contract with O. J. Jennings, of Dunkirk, N. Y., for furnishing all labor and material excepting iron, for construction of a section of the breakwater and for dredging channel, dated June 18, 1873, expired June 30, 1874.

Contract with Cartwright, McCurdy & Co., of Cleveland, Ohio, for furnishing iron material for construction of a section of the breakwater, dated June 18, 1873, expired November 30, 1873.

Abstract of contracts for each class of material and labor.

O. J. Jennings:

1. Hemlock timber, M feet board-measure.....	\$19 00
2. Pine timber and lumber, M feet board-measure.....	25 00
3. Oak timber and lumber, M feet board-measure.....	40 00
4. Crib-framing, &c., linear foot.....	14
5. Superstructure framing, linear foot.....	14
6. Fitting, &c., planks and joists, 1,000 feet board-measure.....	12 00
7. Stone in the work, cord.....	8 00
8. Dredging sand, cubic yard.....	25
9. Blasting and removing rock, cubic yard.....	2 00

Cartwright, McCurdy & Co.:

1. Nut-screw and washer-bolts, pound.....	7 ¹⁵ / ₁₀₀ ¢
2. Drift-bolts, pound.....	3 ¹⁵ / ₁₀₀ ¢
3. Do. washer headed and pointed, pound.....	3 ¹⁵ / ₁₀₀ ¢
4. Spikes, pound.....	5

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$30,000 00
Amount in hands of officer and subject to his check.....	8,736 80
Amount appropriated by act approved June 23, 1874.....	35,000 06
Amount expended during the fiscal year ending June 30, 1874.....	36,130 50
Amount available July 1, 1874.....	37,606 30
Amount required for the fiscal year ending June 30, 1876.....	100,000 06

E 16.

IMPROVEMENT OF BUFFALO HARBOR, NEW YORK.

The work of improvement during the working season of 1873 was confined to efforts to continue the breakwater, which had progressed with difficulty ever since a yielding foundation had been attained. The damages inflicted by the gale of September 30, 1872, were repaired and the line of work of that year rectified. One hundred running feet of work was also laid upon the stone foundation prescribed by the board of engineer officers of April, 1873, and 250 feet additional stone foundation laid.

The work at the close of the working season, 1873, stood 2,499 feet complete; the 100 feet of submerged work built upon the foundation prescribed by the board of engineer officers of April, 1873, showing no sign of settling under the effect of moderate gales, having been built up to its full height and incorporated into the finished work. On the 4th of December, 1873, a gale of wind occurred, the most severe experienced at Buffalo for many years. This gale damaged very extensively the work repaired in 1873, leaving it in a very insecure state, and totally wrecked the superstructure over the last 50 feet of it, while the work of 1873 was completely torn away, removed from its place, and submerged, the stone foundation upon which it rested having been partly dispersed and partly crushed down into the soft mud substratum. For details of this catastrophe I respectfully refer to the reports of the board of engineer officers of December, 1873, which were directed to consider a project for the continuation of the breakwater in addition to their original duty, the providing against the accretion of sand at the mouth of Buffalo River. The gale of December 4, 1873, left the work standing with 2,335 feet completed, but the superstructure over the work of 1872 is in a very insecure condition, having lost a great deal of its stone. Beyond this extended 178 feet of crib-work, from part of which the superstructure had been torn, and over the last hundred feet had been submerged, having been carried down with the cribs. The work was secured as well as the weather would permit, and so remained to the close of the fiscal year. In carrying out the project of the board of April, 1873, as to placing a stone foundation for work succeeding that of 1872, it was found that large quantities of stone were swallowed up in the miry bottom before the height of foundation prescribed by the board could be obtained. Also, in repairing the damaged work of 1872, it was found on getting into the work that the damage was much greater than had been anticipated. In consequence the appropriation of 1873-'74 was exhausted before the superstructure over the work of 1873 could be completed, leaving the work without funds and in an unsafe condition. Mr. D. E. Bailey, contractor for the work for a series of years, and then contractor under the provisions of act of Congress, dated April 15, 1871, probably presuming upon the future operation of that act, and not desiring to disband his experienced gang of workmen, which had been employed on the breakwater since its beginning, upon the appropriation for the work being exhausted, applied to me, and received permission to continue the work in the prescribed manner on his own responsibility, it being distinctly understood that this permission on my part in no way bound the United States through my agency. He built the superstructure over the unfinished work, secured the work for the season, and after the gale of December 4, 1873, repaired damages as far as the weather would permit, getting the work into a state of partial security. The total expense incurred by him outside of his contract, estimated at his contract rate, was \$23,287.76. I mention this in case it should be decided to reimburse him out of subsequent appropriations; and it is not too much to say that, but for his action it is probable that the gale of December 4, 1873, and subsequent gales (the work being left unsecured) would have completely wrecked the work of two years, inflicting a damage additional to that which was, in fact, experienced, falling probably not far short of the amount advanced by him in completing and securing the work after the appropriation of 1873-'74 had been exhausted.

A board of engineer officers was convened at Buffalo, N. Y., December 10, 1873, to consider a project for the prevention of the accretion of sand mentioned in my last annual report. Their action on this subject is re

corded in their reports made at the close of each of their sessions. The gale of December 4, 1873, precipitated affairs by suddenly piling, in one day, a large quantity of sand at the head of the south United States pier in such a manner that the ice breaking up in the coming spring could not fail to sweep it into the channel in greater or less quantities. The appropriation for Buffalo Harbor being exhausted, I called the attention of the city authorities to the subject, advising them to increase their annual appropriation to meet the emergency. They, however, in turn, importuned Congress through the member of their district, and a special appropriation of \$20,000 was made to provide for the removal of the impending bar before opening of navigation in 1874. As there was no time to advertise for proposals, immediate action being required, I threw the removal of the portion most threatening the channel into open market, resulting in an engagement with George Talbot, of Buffalo, at the rate of 50 cents per cubic yard, the best terms I could obtain. The removal of the remainder, after the opening of navigation, was placed in competition after due course of advertising, and resulted in a contract with Spalding and Bennett, of Buffalo, at 25 cents per yard. At the close of the fiscal year all danger of encroachment on the channel had ceased, and its recurrence was fully provided against.

The winter of 1873-'74 being a very open one, the ice did not form at its usual thickness, nor did it mass as heavily in bergs as usual, but floated up and down the lake in their fields of hard formations. These fields impinging on the breakwater during the winter, and breaking up in spring, cut into the timber near the water-line, abrading the work throughout its whole extent, and threatening eventually to cut it completely through. It is, therefore, apparent that it must be protected in some way. A sheathing of $\frac{1}{2}$ -inch iron-plating for two feet above and below water-line will effectually protect the work, and is accordingly recommended to be incorporated in the project for 1874-'75. An appropriation of \$75,000 having been made for this harbor by act of June 23, 1874, it is proposed to expend it during the fiscal year 1874-'75 in building a catch-sand pier of pile and crib-work, of a total length of about 1,300 feet, which will check the movement of sand along the south beach. The damaged south end of the breakwater will also be put in good condition, and if sufficient funds remain available, the iron-plating will be put on the lake side of the work, as a protection from ice. As to the further improvement of this harbor, at the close of the fiscal year a project was in contemplation by the Board of December, 1873, the scope of whose duties had been enlarged to a general consideration of the necessities of the harbor. Upon the result of their deliberation, and the action of the Chief of Engineers upon the same, further improvement will depend.

Amount required for entire and permanent completion of breakwater.	\$2,000,000
Amount that can be profitably expended during the fiscal year ending June 30, 1876.....	500,000

Buffalo Harbor is located in the collection-district of Buffalo Creek, New York, is near Fort Porter, N. Y., has a light-house on south United States pier, a beacon on the middle reef at entrance to Niagara River, and a beacon at north end of United States breakwater.

Amount of revenue collected at Buffalo during fiscal year ending June 30, 1874, \$431,536.29.

Entrances and clearances during fiscal year ending June 30, 1874, 9,860.

Tonnage of same, 4,615,250.

ABSTRACT OF CONTRACTS.

Contract with D. E. Bailey, of Buffalo, N. Y., for furnishing all material and labor for construction of a section of breakwater, and dated April 24, 1873, expired June 30, 1874.

Abstract of contracts for each class of material and labor for construction of a section of the breakwater.

1. Piles, per lineal foot	\$0 25
2. Timber and lumber, per M feet, board-measure	19 98
3. Screw and washer bolts, per pound.....	4½
4. Drift-bolt iron, per pound	3
5. Spikes, per pound	5
6. Preparing and driving piles, per pile	5 00
7. Crib, framing, &c., per lineal foot, timber	12
8. Superstructure, framing, &c., per lineal foot, timber	12
9. Planks, joists, &c., fitting, fastening, &c., per M feet, board-measure	7 00
10. Stone furnished and put in work, per cord	6 85

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$45,000 00
Amount in hands of officer and subject to his check, (including \$2,037.94 percentage due on contracts not yet completed).....	10,301 83
Amount appropriated by acts approved February 25 and June 23, 1874....	95,000 00
Amount expended during fiscal year ending June 30, 1874	73,000 68
Amount available July 1, 1874	77,301 15
Amount required for the fiscal year ending June 30, 1876	500,000 00

E 17.**BUFFALO HARBOR, NEW YORK.***Report of Board of Engineers.***UNITED STATES ENGINEER OFFICE,
Buffalo, N. Y., March 23, 1874.**

GENERAL: The board of engineer officers, constituted by Special Orders No. 156, dated Headquarters Corps of Engineers, Washington, D. C., November 28, 1873, assembled, as directed, at Buffalo, N. Y., on the 10th day of December, 1873, all the members being present. After a cursory examination of the maps, plans, and miscellaneous data laid before them by the engineer officer in charge of Buffalo Harbor improvement, the board proceeded to visit the harbor, inspect the breakwater, examining into the condition in which it was left by the gale of December 4, 1873; they also inspected the bar at the head of the south United States pier. The board found at this point extensive shoaling, threatening in time to obstruct the entrance into Buffalo River. After discussing generally at some length the subjects presented for their consideration, the board came to the conclusion that there was not sufficient data before them upon which to base a definite decision upon the several important points on which they were called upon to report. They, therefore, requested the officer in charge of Buffalo Harbor improvements to make certain examinations and surveys tending to throw more light upon the question of how best to meet the difficulties presented in prosecuting the improvement of Buffalo Harbor, and then adjourned subject to the call of the senior member whenever the data which they had requested should be ready for their consideration. These data having been collected during the winter of 1873-'74—but very imperfectly, owing to lack of available funds to defray the expense of minute examination—the board reconvened March 20, 1874, and proceeded to a careful and deliberate consideration of the matters in question. The result of their deliberations, by aid of the imperfect data afforded them, is respectfully submitted in the following

REPORT.

In order to convey a full idea of the engineering-difficulties encountered in prosecuting the improvement of Buffalo Harbor, the board desire to preface their report on each subject referred to their consideration with a brief account of the condition of that particular portion of the improvement at the date of their sessions.

The board is called upon to report upon two distinct subjects, connected, however, in their relations to the general scheme of improvement. The board will, therefore, first discuss these subjects separately and then together in relation to a general project for the improvement of the harbor.

I.—THE ACCRETION OF SAND.

The first subject the board is called to report upon is the accretion of sand at the head of the south United States pier. The board, at their first session, December 10, 1873, found the anticipations contained in the several reports of Major Harwood to the Chief of Engineers upon this subject fully realized. As a result of the very violent gale, which occurred just prior to their session, a large quantity of sand was transferred from the front of the sea-wall to the head of the south United States pier, where it was deposited in a bar, extending westwardly toward the breakwater, from the pier-head on the prolongation of the axis of the extension of the south United States pier, about 350 feet, and having not quite 3 feet of water over its apex. Although this bar did not then infringe upon the channel, it was in position to be transferred into it should moving ice scrape over its surface. During the recess of the board the question of the disposal of this bar was taken out of their consideration by an act of Congress appropriating \$20,000 for its removal, and at the board's session of March 20, 1874, the board found dredges already at work upon it.

The question still remains as to what shall be done to prevent future encroachment of sand on the channel at the mouth of Buffalo River. A strip of beach about 100 feet in width in front of the sea-wall is covered with sand, and extends southward beyond the south channel region for several miles. From this beach a constant supply of sand may be expected at the south pier-head, unless the northward transfer along the beach in gales of wind be prevented by some interposing obstacle.

The board approve the project of Major Harwood to arrest this progress of sand along the beach by building a catch-sand pier at the south channel region, as indicated on the map herewith submitted, and which forms a part of the general project for the improvement of Buffalo Harbor.

The board recommend for this work a pile-pier, 10 feet in width, covered by 6 feet of superstructure, extending to the 12-foot curve of water, thence prolonged in the same direction by crib-work 20 feet in width, covered with 6 feet of superstructure, to the point B, indicated on the map. The board adopt this slight cross-section for the pile-pier, hoping that the accretion of sand about the work will give it ample stability. The shore end of the pile-pier is recommended to be connected with the railroad bulk-head immediately in its rear by a close row of piles. The board in this connection do not take into consideration the project for a south channel into Buffalo River, leaving that to be effected by such private interests as may in the future be most benefited by it.

In addition to the catch-sand pier recommended by the board, it is

expected that other jetties of slight construction, not to exceed 300 feet in length, may be needed at different points between the site of the one now proposed and the south United States pier, to arrest the transfer of sand and prevent abrasion of the beach during the period in which covering-works are in process of construction. No estimate is, however, made for these jetties at present.

II.—THE BREAKWATER.

The board, at its session December 10, 1873, found that the same violent gale which caused the bar at the south United States pier-head likewise damaged extensively the southerly end of the breakwater. The two end cribs, each 50 feet in length, 34 feet wide, and 23 feet in depth, covered with completed superstructure 8 feet in height, and resting upon rubble-stone foundation, were torn away from other work to which they were bonded by the superstructure, deviated harborward from the general line of work 16 feet, and sunk into their bed to a depth of 8 feet, leaving the top of their superstructure about at ordinary water-level; the whole section of 100 feet standing with but a slight list to lakeward. As the deck of the superstructure over one crib at least was found to be intact, it is presumed that the bulk of the stone remained in the mass while it was changing its position. The superstructure of the work of the last season, built up during the working-season of 1873, was also damaged, and a large quantity of stone swept out. At the session of the board March 20, 1874, the damaged superstructure had been repaired and refilled with stone, but the southerly end, the submerged work, consisting of one crib of 1872 from which the superstructure and a repair-crib had been torn, and the two submerged cribs of 1873, with their superstructure, also submerged as heretofore described, remained still untouched.

The examinations desired by the board at its session of December 10 1873, have not been finished, from the fact that the appropriation for the work was exhausted. The prolongation of the line of that part of the breakwater already completed passes through an area of soft muddy bottom which offers great difficulties in foundation. Before deciding to attempt to cross this area, necessarily at great expense, or adopting the alternative plan of leaving a large gap in the breakwater, the board deems it necessary to have a thorough examination, by borings, of this soft area and its vicinity, to ascertain if it cannot be avoided by some change of the trace adopted by the board of engineer officers of March, 1868, and recommend that the local engineer make these examinations as soon as he has the needed funds. As soon as these examinations are completed, and the results laid before the board, they will be able to submit a definite plan for a continuation of breakwater work, but with their present imperfect information they are unable to prepare any plans or make any estimates. Such plans and estimates must necessarily be the subject of consideration at a future session of the board. In the meanwhile, however, the board recommend that the southerly submerged section of the breakwater be built up to its full height of 8 feet above low-water level, and in plan as indicated on the accompanying drawing. The board is impressed with the failure of the present project (that of 1868) for a breakwater to fulfill all the requirements of an outer harbor at Buffalo. The breakwater, it is true, has furnished sheltered anchorage, but the accumulation of sand at the entrance of the inner harbor, a point covered from the direct action of the lake waves by the portion of break-

water already finished, shows the necessity of connecting the breakwater with the shore to cut off the shifting sands from the southward. The board, therefore, favor the general project of Major Harwood for the completion of the outer harbor, reserving estimate until more detailed examinations are made and reported upon. We, however, respectfully submit the following estimates for the projects we have matured :

The catch-sand pier.

950 running feet pile piercing, at \$30	\$28,500
340 running feet crib piercing, at \$70	23,800
Total	52,300
Add 10 per cent. contingencies	5,230
	57,530
Estimate for catch-sand pier	\$58,000

Breakwater.

Building up the southerly submerged end to full height of main work in plan as proposed by the board.....	\$25,000
---	----------

The board respectfully return the papers and map submitted for their consideration, having given them all careful attention, and also due weight to the suggestions of Messrs. Beaseley and Bennett referred to us by the Chief of Engineers. The papers returned are enumerated in the accompanying schedule, and the maps to accompany this report will be forwarded as soon as they can be prepared. Respectfully submitting this, our preliminary report, the board adjourn subject to the call of the senior member, whenever the full examinations requested by the board shall have been made, and the results ready to be laid before them.

We have the honor to be, very respectfully, your obedient servants,

I. C. WOODRUFF,

Colonel of Engineers, Bvt. Brig. Gen. U. S. A.

C. B. COMSTOCK,

Major of Engineers, Bvt. Brig. Gen.

JOHN M. WILSON,

Major of Engineers, Bvt. Col. U. S. A.

F. HARWOOD,

Major of Engineers, Bvt. Lieut. Col. U. S. A.

Brig. Gen. A. A. HUMPHREYS,

Chief of Engineers, U. S. A.

E 18.

HARBOR OF REFUGE AT CLEVELAND, OHIO.

UNITED STATES ENGINEER OFFICE,
Buffalo, N. Y., December 31, 1873.

GENERAL : In accordance with the provisions of act of Congress approved March 3, 1873, and your subsequent instructions, I have completed the survey for a harbor of refuge at Cleveland, Ohio, and have

now the honor to submit the result of my investigations in this my report, and the map forwarded this day on roll.

To construct a harbor of refuge at Cleveland, a breakwater or system of breakwaters would evidently be needed. The location and course of such work or works as might be decided upon would depend primarily upon the general direction of the heaviest attack of the waves.

Secondarily, however, another point comes into consideration. Cleveland being a city of large population, and having a large commerce, with very limited harbor facilities, all of her shipping being necessarily crowded in the Cuyahoga River and adjacent slips, it would evidently be advantageous to commerce in general, and Cleveland commerce in particular, to locate the harbor of refuge in such a manner as not only to subserve its primary intention, but also incidentally to relieve somewhat the overburdened inner harbor, and protect its entrance in heavy weather, preventing effectually the casualties now constantly occurring to vessels attempting to enter during storms.

Keeping, then, these points in view, regarding the location and direction of covering-works, there was still to be borne in mind the fact that the character of construction, and consequently the expense of building, might be greatly modified and perhaps advantageously reduced by a slight change in the site.

To determine all these points a careful and elaborate survey was required, establishing the shore-line in the vicinity of the Cleveland piers, carefully sounding the water-front as far as necessary to establish the curve of 36 feet of water, and at stated points driving a hollow rod into the bottom of the lake to determine the character and density of the soil. These operations I intrusted to Mr. George E. Fell, assistant, upon whom I could implicitly rely for accuracy and thoroughness, he having given evidence of his ability and faithfulness in many surveys about Buffalo and Dunkirk, N. Y., since 1867. The results of his labors are incorporated in his map, herewith transmitted.

It now only remains for me to report my conclusions and reasons for the same. The facts determined by this survey are as follows:

Cleveland is situated on the south shore of Lake Erie, Buffalo, at the eastern extremity, being about twice as distant as the mouth of the Detroit River at its western.

Its water-front is attacked by prevailing storms, from both the eastward and westward, the effects of the attack from the northwest being, however, by far the most severe.

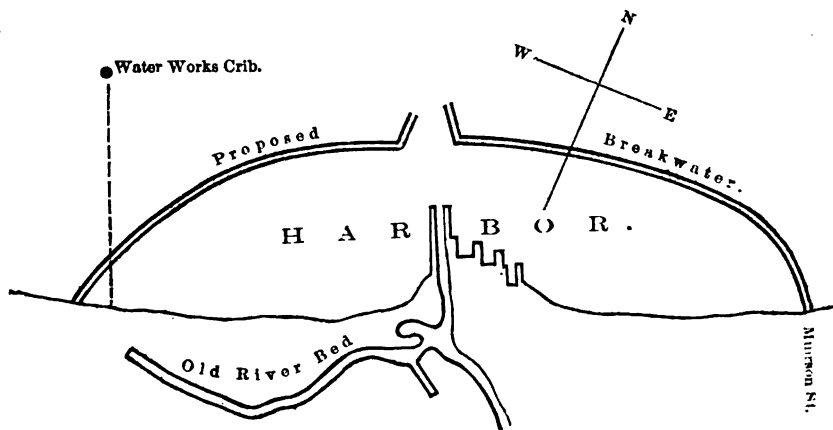
It was also ascertained by careful examination that the bottom of the lake, all along the water-front, consists of a loose deposit of soft blue clay, silt, and sand, no rock or firm foundation of any character being found within 25 feet of the upper surface at any point, which might be expected, inasmuch as the Cuyahoga River has for years been carrying the alluvium from its headwaters, re-inforced by the sewerage of the city, into the lake frontage, where, there being no littoral current of any magnitude, and such as there is being neutralized as to its effects by the waves coming invariably from different quarters, it is of course deposited along the water-front. This fact will seriously affect the cost of any structure which may be determined upon, no matter where located, but this I will fully discuss further on. To illustrate I have only to cite the difficulties encountered by the water-works engineers in constructing their tunnel and inlet pier. At or near the point marked X on the map they drove a rod to find the rock, but after penetrating about 100 feet, and finding none, gave it up and ran out a brick tunnel to the inlet pier noted on the map. In sinking the crib at this point they encountered

the same difficulties lately met at Buffalo. The crib went down into the soft soil 11 feet, and it was only after heavy riprapping that a firm foundation has apparently been attained. Like difficulties will, of course, attend the construction of a breakwater on a like foundation, and although the full force of Lake Erie, coming from one direction, would not be felt as at Buffalo, I anticipate similar difficulties in construction, perhaps in a minor degree, to those now being encountered in continuing the Buffalo breakwater.

With facts thus stated before me, I arrived, after discussion with the Board of Trade of Cleveland, and careful consideration of all the points of the case, at the conclusion indicated upon the map, in plan and cross-section. Before proceeding, however, to describe this project, I will refer to others which came to my attention in the course of my investigations, and which, although I reject, for reasons I will state, yet are well worthy of consideration, as it may be that I have overlooked points in their favor which, duly considered by reviewing authority, might annul the objections I make to them.

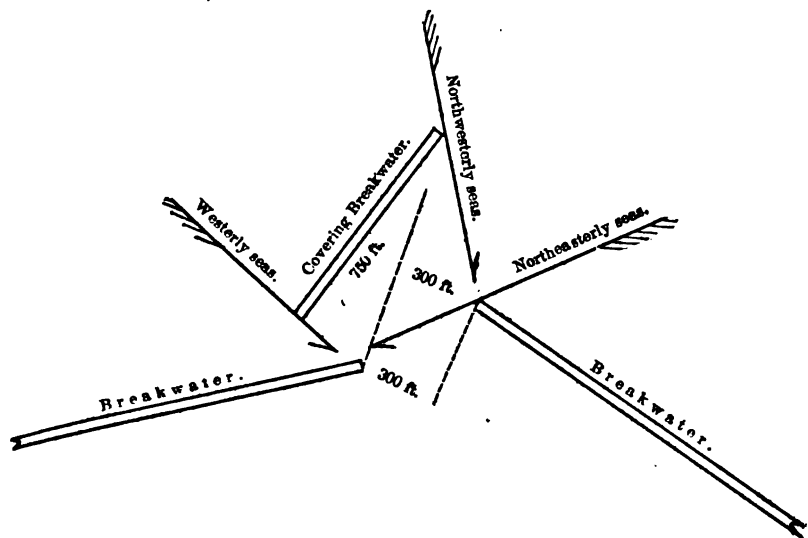
First, I will refer to the project submitted to my attention by the Board of Trade of Cleveland, which was simply an elaboration of the crude project I had already formed in my mind without the aid of the survey, then incomplete. This consisted of two breakwaters about 3,000 feet distant from the present pier-heads, approaching each other to a distance of 300 feet, just opposite the present entrance to the harbor; at these ends branches to project into the lake sufficiently far to prevent the waves breaking in behind the works.

The following sketch illustrates the idea :

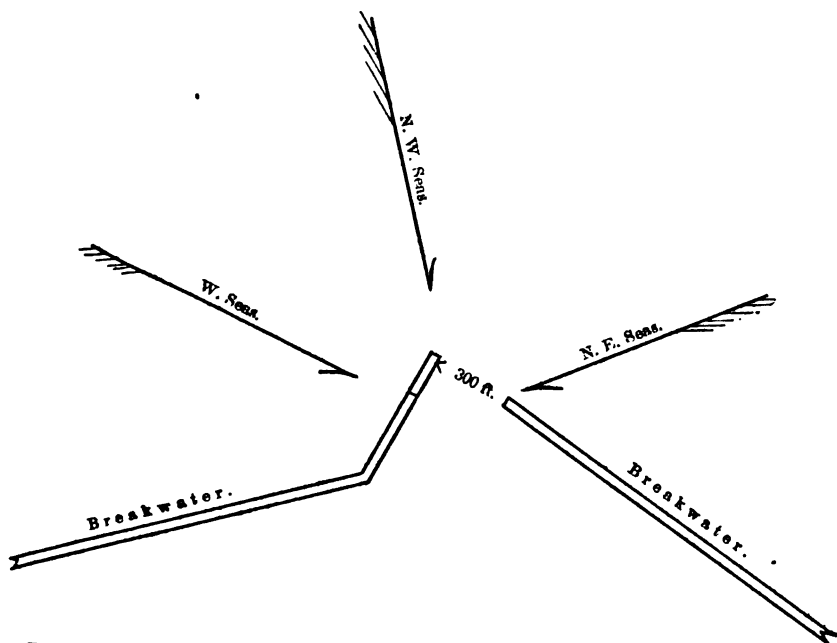


My objection to this is the increased, and, to my mind, unnecessary expense of the construction of the lakeward arms, obviated in the project I have fixed upon; also the reproduction of difficulties of entrance between two nearly parallel piers, due to the cross-swash always produced in stormy weather. The Board of Trade's original plan contemplated prolonging the breakwaters on a curve to the shore, making a snug harbor; but this idea was abandoned upon my representing the evidently enormous expense of the project. The second and only other feasible project brought to my attention was a modification of the former, proposed by Capt. P. C. Watmough, formerly an officer of the Navy, and now collector of customs at Cleveland. Noting the cross-swash

difficulty, he proposes to substitute a covering breakwater for the two awkward branches, thus :



NOTE.—If such a combination should be determined upon, I prefer the modification I give below, which, in my opinion, is decidedly the best in the case where a central exit is afforded to vessels. I have accordingly indicated it upon the survey. It can be constructed at nearly the same expense as the continuous work.



To this I interpose the same objection of expense as before, and, in addition, the point that the design I now submit has all the advantages

of his combination, without the drawback of having the work nearly useless until completed, and constantly more endangered while in process of construction than a continuous work would be. By beginning the construction I propose at the angle, and working both ways, a lee will be obtained rapidly, the work will be of use almost from its beginning, and will be of increased utility year by year until its completion.

I will now proceed to explain my reasons for its location, and describe the same.

Experience at Buffalo has shown that vessels may come to in heavy weather under the lee of a breakwater, distant perpendicularly 2,200 feet from the nearest pier-head. But in projecting an important work to accommodate the wants of a rapidly-increasing commerce for an indefinite series of years, I considered it proper to estimate for the maximum area of anchorage, especially when the soundings show that increased area can be obtained at but trifling increase of expense. I accordingly fixed upon 3,000 feet as the perpendicular distance from pier-head to breakwater.

The attack of the waves coming from two general directions, two branches are needed to the breakwater. To give ample accommodation to a fleet of vessels coming from either direction under stress of weather, I fixed upon 4,000 feet as a commodious length for each arm, putting it at a maximum, as in the former case; but in this it is to be observed that, by building from the angle, the length of each arm may be varied to suit the wants of commerce from time to time. To thoroughly cover the present entrance to the harbor from the attack of waves, I considered it necessary to prolong each arm of the breakwater 400 feet shoreward from its intersection with a line drawn from each pier-head, severally, in the direction of the prevailing incoming wave on that quarter.

For convenience in locating the work, I have placed the angle, the initial point, on the prolongation of the axis of the present east pier of entrance. Hence results the location.

The cross-section I should recommend will greatly depend upon the conclusions arrived at by the board of engineer officers now studying the difficulties presented in building upon a similar foundation at Buffalo, N. Y.

As a basis, however, for estimate of expense, I have indicated on the map a cross-section of tried stability. It is that of the Buffalo breakwater, modified to meet the requirements of the increased width necessary for the increased depth of water. The Buffalo breakwater will stand in from 21 to 30 feet of water; the proposed Cleveland work would stand in an average of about 34 feet. The Buffalo breakwater is 34 feet wide; I project the Cleveland work at 40 feet. The only other modification I make, in the Buffalo cross-section, is to put two longitudinal walls in superstructure, bonding with the one in crib, a measure which experience has shown very desirable in a work of this character.

Any estimate I might form of the expense of the work, I suppose, would be mere conjecture, the grounds of computation are so uncertain, especially when building upon yielding soil. The original estimate of cost per lineal foot of the Buffalo breakwater has, by reason of coming upon a loose foundation, more than doubled, by reason of casualties incidental to an unstable basis. The primary conditions at Buffalo and Cleveland, although not exactly the same, would, in my opinion, nearly counterbalance. Buffalo has the heavier attack of the waves, but Cleveland, on the other hand, has the least favorable foundation for the work. While, therefore, I refrain from attempting to make a close estimate,

an approximate one may be arrived at from comparison of the present theoretical expense of the construction per lineal foot of the Buffalo breakwater with that of a similar structure at Cleveland, bearing in mind the greater depth of water at Cleveland, and consequent greater projected width of the work, and doubling the estimate for foundation, a conclusion fully warranted by the doubly treacherous foundation upon which the work must rest.

I respectfully submit herewith a comparative statement showing in detail the theoretical cost per lineal foot of the Buffalo breakwater built on the plan as modified by the board of engineers of April 9, 1873, and an estimate for a similar construction at Cleveland, modified and calculated as I have above stated.

It is probable, however, that the deliberations of the board of engineer officers now studying the Buffalo question will result in conclusions which will increase these estimates about 25 per cent., if not more.

The following is the summary of my conclusions:

In my opinion, for a harbor of refuge at Cleveland, Ohio, a breakwater is required of rectangular cross-section 40 feet in width, standing in an average of 34 feet of water, to consist of two arms starting from an initial point on the prolongation of the axis of the present east pier of entrance, each arm to be 4,000 feet in length, to be 3,000 feet distant in a perpendicular direction from the opposite pier-head of the present harbor, and overlap shoreward a line drawn from said pier-head in the direction of prevailing incoming waves, 400 feet.

Estimated cost per lineal foot, approximate and maximum, \$500.
Total approximate cost, \$4,000,000.

All of which is respectfully submitted, and I have the honor to be, general, very respectfully, your obedient servant,

F. HARWOOD,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Theoretical cost (with no allowance for settling or contingencies) of 50 feet of Buffalo breakwater.

139,875 feet board-measure timber and lumber, at \$20.....	\$2,797 50
11,491 lineal feet framing, at 12 cents.....	1,426 92
2,576 feet board-measure, joists and plank, fitting, &c., at \$7.....	20 13
32,197 pounds drift-bolt iron, at 3½ cents.....	1,247 63
630 pounds spikes, at 5½ cents.....	37 40
435 cords stone, at \$6.85.....	2,979 75
Cost for 50 lineal feet.....	8,509 33
Cost per lineal foot.....	\$170 00

Calculated at present contract-rates of material and labor for Buffalo Harbor, New York.

Official:

F. HARWOOD,
Major of Engineers.

Theoretical cost of 50 feet (one crib length) of breakwater for Cleveland, Ohio, work to be 40 feet wide, to be built in 34 feet depth of water, with stone foundation of 4 feet depth, doubling the estimate for stone foundation over that of a similar structure at Buffalo to meet the greater difficulty of a more yielding site.

MATERIAL.

186,550 feet board-measure timber and lumber, at \$20 per 1,000 feet board-measure	\$3,731 00
756 pounds wrought-iron spikes, at 8 cents per pound	60 48

LABOR.

14,020 lineal feet timber, at 12 cents per lineal foot	1,682 40
34,135 pounds drift-bolt iron, at 6 cents per pound	2,048 10
669 cords of stone, at \$9 per cord	6,051 00
6,310 feet board-measure plank and joists, at \$12 per 1,000 feet board-measure	75 72
Cost for 50 lineal feet	13,648 70
Cost per foot	\$273 00

NOTE.—This is calculated at current rates of material and labor at and near Cleveland, Ohio.

No contingencies are reckoned, it being impossible to get a reliable basis of calculation. I estimate, however, that \$500 per lineal foot will cover all expenses, making the total maximum cost of the harbor \$4,000,000.

F. HARWOOD,
Major of Engineers.

APPENDIX F.

ANNUAL REPORT OF MAJOR JOHN M. WILSON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1874.

UNITED STATES ENGINEER OFFICE,
Oswego, N. Y., July 11, 1874.

GENERAL: I have the honor to transmit herewith the annual reports for the fiscal year ending June 30, 1874, of the various works of river and harbor improvements under my charge.

I am, general, very respectfully, your obedient servant,

JOHN M. WILSON,
Major of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

F 1.

OLCOTT HARBOR, NEW YORK.

HISTORY OF THE WORK.

In 1846 the first survey under the General Government was made under the direction of Col. Wm. Turnbull, of the United States Corps of Topographical Engineers, and a plan for the improvement of this harbor was submitted. The business of the place was unimportant, though private enterprise had already extended a pier 250 feet into the lake,

and the claim for improvement was based upon the need of a harbor of refuge, the nearest available ports at that time being Niagara, eighteen miles west, and Genesee, sixty miles east.

In September, 1866, a resurvey of the harbor was made under Lieut. Col. Charles E. Blunt, and a plan of improvement submitted. It was proposed to contract the mouth of Eighteen Mile Creek, which here empties into the lake, by two parallel piers, two hundred feet apart, and extending one thousand feet out into the lake; to dredge a channel between them, and to form a harbor inside by excavating in the creek. The survey showed a bar extending across the mouth of the creek, upon which there was a depth of only $1\frac{1}{2}$ feet of water.

Congress, in 1867, made an appropriation of \$60,000 for this work, and contracts were made and operations commenced in the fall of that year, constructing the piers.

The survey for the Niagara Ship-Canal, made during that year, showed this point to be an available one for its terminus, and that Olcott might become a place of some prominence.

Operations were carried on under contract in 1868, and at the close of that season the west pier was 345 feet long, 275 feet being complete, and 70 feet without superstructure; two cribs had also been sunk on the line of the east pier, and a channel dredged so that vessels drawing seven feet could enter the creek.

Lieut. Col. Blunt was relieved in January, 1869, and the charge of this work, as well as that of others under the control of the Chief of Engineers upon Lake Ontario, passed through the hands of Major McAllister and Captain Harwood to Major Bowen, who assumed charge in May, 1869. Major Bowen immediately annulled all contracts, and commenced the prosecution of the work by hired labor.

In 1870 an appropriation of \$10,000 was made, and work vigorously prosecuted, so that by the close of that season the piers were each 610 feet long; the superstructure, however, upon 100 feet of the west pier and 220 feet of the east was incomplete; no dredging was done other than that necessary to prepare foundations for cribs.

In January, 1871, Maj. John M. Wilson assumed charge of the work, and in March of that year an appropriation of \$5,000 was made, and the extension of the piers was continued under contract.

At the close of the season of 1871 the west pier was 791 feet long, and the east pier 731 feet long. Borings made between the piers during this season developed an extensive bed of red sandstone stretching across the channel, having upon it a depth of only 7 feet at low water; it was estimated that to obtain a channel 150 feet wide and 12 feet deep would require the removal of 7,600 cubic yards of this rock, besides about 12,000 cubic yards of sand, gravel, &c., and \$50,000 was asked to complete the project.

In 1872 an appropriation of \$10,000 was made, and the prolongation of the piers continued, so that at the close of the fiscal year ending June 30, 1873, the west pier was 881 feet long, and the east pier 851 feet long, a portion of the superstructure of both piers being yet incomplete.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1874.

An appropriation of \$10,000 was made in March, 1873.

The opening of the fiscal year found operations in progress under contract with H. J. Mowry, constructing superstructure upon cribs previously sunk. Operations were continued until early in August, when they were closed, the pier-work being completed; during this period

the superstructure of the west pier was filled with stone and decked over on a length of 90 feet of the pier, and that of the east pier entirely constructed on a length of 120 feet of the pier.

In performing this work the following materials were used :

126 feet, board-measure, hemlock timber.
35,392 feet, board-measure, pine timber.
13,383 feet, board-measure, pine plank,
2,742 pounds drift-bolts.
616 pounds spikes.
121 cords of stone.

In March, 1873, proposals were invited for opening the channel between the piers, by removing rock, sand, &c.

No bids were received, and by authority of the War Department a dredge was hired, and the work carried on by the day. The dredge was brought from Lake Erie, through the Welland Canal, and operations were commenced on the 9th of August, and continued until the 28th of October, when they were suspended on account of the weather.

During this period a channel 60 feet wide and 880 feet long was dredged between the piers, and one 20 feet wide, 650 feet long, and 12 feet deep from the bridge to the piers; the full depth of 10 feet at low water was obtained between the piers until a point was reached 560 feet from the inner end; here the bed of red sandstone was encountered. The dredging was exceedingly difficult from this point to the outer ends of the piers, a distance of 320 feet, and the depth gained was from 7 to 9 feet at low water.

Operations were suspended October 28, 1873, and in November a survey of the harbor was made. A beacon, showing a fixed white light of the fourth order, was placed on the west pier in the fall of 1873.

Operations were resumed, dredging the inner harbor between the bridge and the piers, in May, 1874, but suspended at the close of the month for want of funds.

The following materials were removed from the harbor by dredging during the fiscal year:

One old crib, 16 by 30 feet, filled with stone.

One boulder, measuring one cubic yard.

The wreck of a vessel sunk fifty years ago.

Two thousand three hundred and eighty-six cubic yards of red shale and rock.

Thirteen thousand four hundred and twenty-eight cubic yards of clay, sand, gravel, and mud.

At present both piers are in excellent condition, the east being 851 feet long and the west 881 feet; they have been carried out to the depth of 10 feet at low water, and it is not intended to carry them farther until the channel is properly opened. Vessels drawing 9 feet can now enter the harbor at ordinary low water, and go up to the store-houses near the bridge. To complete the project the piers should each be prolonged 120 feet, the channel opened between them by removing rocks, &c., and the creek between the bridge and piers dredged out to form a harbor.

During the present season it is proposed to open a channel 50 feet wide between the piers by removing 2,578 cubic yards of rock.

The original estimate for the improvement of this harbor was \$118,000.

Up to the close of the fiscal year ending June 30, 1874, \$105,000 had been appropriated, of which \$94,988.68 has been expended. Thirty thousand dollars will still be required to complete the work. The excess arises from the fact that since the original estimate was made the bottom of the channel between the piers has been found to consist of

red sandstone rock, the cost of the excavation of which exceeds greatly that of ordinary material.

Olcott is a port of entry in the collection-district of Niagara. The nearest fort is Niagara. There is a beacon showing a fixed white light of the fourth order, on the outer end of the west pier.

The amount of revenue collected during the fiscal year was \$697.

The value of the imports was \$3,290. There were no exports.

Twenty-five vessels, with an aggregate tonnage of 1,462 tons, entered and cleared during the year.

The value of the lumber and produce shipped coastwise from the port during the year was \$45,626.50.

An abstract of contracts in force, and a financial statement, are transmitted.

Financial statement.

Balance in Treasury of the United States July 1, 1873.....	\$10,200 00
Amount in hands of officer and subject to his check, (including \$724.99 percentage due on contracts not yet completed)	1,531 76
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874	11,720 44
Amount available July 1, 1874	10,011 32
Amount required for the fiscal year ending June 30, 1876.....	30,000 00

Abstract of contracts for improving harbor of Olcott, N. Y., in force during the fiscal year ending June 30, 1874, by Maj. John M. Wilson, Corps of Engineers, United States Army.

Name of contractor and residence.	Date of contract.	Subject of contract.	Timber and plank.				Iron.		Stone, per cord.	Labor.			Remarks.	Contract closed, July 31, 1873.
			Hemlock, per 1,000 feet, board-measure	Pine, per 1,000 feet, board-measure.	Oak, snubbing-posts, per lineal foot.	Spikes, per pound.	Wrought-iron washers, per pound.	Timber-work, per 1,000 feet, board-measure.		Iron-work, per pound.	Driving tree-nails, each.			
Henry J. Mowry, Syracuse, N. Y.	1872. Aug. 23	Material and labor	\$23 00	\$28 00	\$0 50	\$0 08	\$0 08	\$8 00	\$7 00	\$ 02	\$0			

F 2.

OAK-ORCHARD HARBOR, NEW YORK.

HISTORY OF THE WORK.

The necessity for a harbor of refuge between the Niagara and Genesee Rivers was brought to the attention of Congress in 1836, and as the mouth of Oak-Orchard Creek possessed advantages both in its position and character, \$5,000 was appropriated for its improvement.

Oak-Orchard Creek takes its rise in a series of extensive marshes, and after leaving these flows through a section, the soil of which is loose and sandy; it has fall enough and a good water-power a few miles above its mouth, but from there to the lake the descent is nearly nothing, and the force of the current at its mouth is not great enough even during freshets to scour the channel.

The original survey in 1836 showed the channel of the creek to be 120 feet wide for two miles inland, and to have a depth of from 12 to 20 feet, but the mouth was closed by a bar upon which there was only from 2 to 4 feet water.

It was proposed to contract the entrance by building breakwaters from each shore running toward each other, to leave an opening 200 feet in width, and to define the channel by parallel piers running out to the deep waters of the lake.

It was anticipated that the spring freshets would scour out this channel, but this was not realized.

Operations were commenced in 1836, and during this year 650 feet of the west breakwater, 10 feet wide, was constructed. In 1837 \$5,000 was appropriated, and the west channel-pier and east breakwater commenced. In 1838 \$5,000 was appropriated, and at the end of that year the east breakwater was completed, and both channel-piers were extended 300 feet into the lake. The current had failed to open the channel, and its action upon it was not anticipated until the piers were prolonged to their full length, 1,160 feet. It was feared that even then dredging would be necessary.

No further appropriation was made until 1844, although repeatedly urged.

In 1842 the piers were reported in good order, and it was considered that if an appropriation of \$12,500 was made the harbor could be made available for vessels drawing 7 feet of water.

In 1844 it was decided that the material in the channel was too heavy to be moved by the current, and it was recommended that \$20,000 should be appropriated for the construction of a dredge for use in this and other lake harbors. The \$5,000 appropriated this year was expended in extending the west pier to the length of 510 feet, and the east pier to 725. The spring freshet of 1845 scoured the channel so that vessels drawing 5 feet entered, but the northeast gales soon filled it to 4 feet again.

All river and harbor improvements were suspended in 1846, and although resumed again in 1848, no further appropriation was made for this harbor until 1852, when \$10,500 was appropriated. This was expended in 1853 under Major Turnbull, rebuilding the west pier and adding 290 feet to its length. No further appropriation was made until 1867.

In the mean time the dredge previously recommended had been built, and in 1857 a small portion of the appropriation of 1852 remaining on

hand, the dredge was sent to Oak Orchard to work in the channel. When the funds were exhausted the inhabitants raised \$1,000 to pay expenses, and work continued until September of that year. Eleven thousand cubic yards of material were removed and a channel 8 feet deep completed. Vessels at once availed themselves of it, and a beacon became necessary. The piers, in the mean time, had become dilapidated and required rebuilding. It was also recommended that they be prolonged to the 15-foot curve in the lake. The amount estimated to complete the work, was \$61,498.

In March, 1867, an appropriation of \$87,000 was made, and the work placed in charge of Lieutenant-Colonel Blunt; a survey was made and plan submitted. It was proposed to rebuild the piers, then nearly destroyed, extend them out to a depth of 12 feet, and to dredge a channel between them. Contracts were made and some materials delivered, but the contractor for the labor having failed to commence the work, his contract was canceled. Lieutenant-Colonel Blunt having been relieved in January, 1869, the work passed through the hands of Major McAllister and Captain Harwood to Major Bowen, who assumed charge in May, 1869.

New contracts were at once made and work commenced on the piers and dredging the channel, three dredges being engaged on the latter work.

In 1870 the west pier had been extended to 955 feet in length and the east pier to 763 feet, and a large amount of dredging had been done. Eight thousand dollars was appropriated to continue the work. A survey of the harbor and approaches showed that vessels drawing 7 feet could enter at low water. A beacon was placed near the outer end of the west pier during the season of 1870.

In January, 1871, Major John M. Wilson assumed charge of the work, and in March of that year an appropriation of \$10,000 was made.

Contracts were at once made for completing the piers and dredging the channel. During this year 152 feet of pier complete was added to the east pier, and 180 feet to the west pier; the incomplete superstructure upon cribs previously sunk on the lines of both piers was also finished.

At the close of 1871 the west pier was 1,135 feet long and the east pier 915 feet, and it was not deemed necessary to prolong them further. The dredge removed from the channel, during the year, 7,656 cubic yards of sand, mud, gravel, cobblestone, hard clay, &c., but could not obtain, over a portion of it, a greater depth than $7\frac{1}{2}$ feet, having encountered a ledge of red sandstone similar to that found at Olcott Harbor.

A survey was made on the ice in the winter of 1871-'72, and the ledge was found to extend across the channel. It was estimated that to obtain a channel 150 feet wide across it would require the removal of 7,850 cubic yards of rock.

In 1872 an appropriation of \$2,500 was made, and a contract entered into for dredging the materials in the channel above the rock. Operations were commenced in June, the work being exceedingly difficult, but by the close of the season 8,019 cubic yards of material had been removed, and a depth of 10 feet at low water obtained, except over the rock, where only $7\frac{1}{2}$ feet could be obtained. Work was also carried on by hired labor, repairing piers and renewing superstructure, and by the close of the fiscal year ending June 30, 1873, the superstructure had been partially renewed upon 200 feet of the west pier and the outer ends properly leveled.

OPERATIONS DURING THE FISCAL YEAR.

In March, 1873, Congress made an appropriation of \$10,000 for this harbor, and in the same month proposals were invited for opening a channel between the piers. The lowest bid being greater than the amount of the appropriation, it was rejected, and, by authority of the War Department, the work was prosecuted with hired labor.

The method used at Ashtabula Harbor, by drilling from a raft and blasting, was adopted, the rock to be afterward removed by dredging.

Mr. James S. Lawrence, a civil engineer of ability and experience, was placed in direct charge of the work, and the result was exceedingly satisfactory. Operations were commenced the latter part of July, drilling and blasting in the channel.

The raft from which the drilling was done was constructed from old timber and iron remaining on hand after completing the piers. Operations were much impeded by the heavy swells from the lake and by vessels passing in and out the harbor, the swells causing a rise and fall as well as a lateral and longitudinal motion of the float, sometimes jamming the drills and at others causing the loss of holes partly drilled, and frequently causing the suspension of work. The passage of vessels also made it necessary to cast off the guys connecting the raft with the piers, which caused loss of holes and time in moving float. To prevent these troubles spuds were fitted to the raft, by means of which it could be raised above water sufficiently to throw its whole weight on the spuds, and the annoyances referred to were thus obviated.

The drilling-apparatus consisted of a 2½-inch drill, 4 feet long, connected by a coupling-screw to a rod 14 feet long, both of 1½-inch iron, and weighing 80 pounds; a 3-inch iron pipe 12 feet long, an iron wrench to connect and disconnect the drill and rod; a sand pump of 2-inch iron pipe, 8 feet long; a spring-pole 20 feet long, and rope to suspend the drill from the pole; we used 6 tubes and 12 drills. Ordinary blasting-powder, at 16 cents per pound, was used, and put into tins anisters 14 to 20 inches long and 2 inches in diameter. The neck of the canister was seven-eighths of an inch in diameter, and closed by a perforated cork, through which the wires of the exploders pass. Two kinds of exploders were used; one from G. M. Mowbray, of North Adams, Mass., the other from Laflin & Rand's Powder Company, of New York.

The electric battery used was one of Smith's 12-inch patent batteries, made by Lincoln & Co., of Boston.

The following is the method used in blasting:

The float is placed in position over the rock, the guys carried to the piers, the spuds put down, and raft raised so as to be as steady as possible. The location having been accurately noted, the men place a tube in position in one of the holes in the float and drive it down to the rock, and, if necessary, clear it out with a sand pump. The tube is kept in position by confining it to one corner of the hole by nailing a strip across and against the pipe; the drill is put in and the upper end made fast to the spring-pole; two men operate each drill; the holes are drilled at least one foot below the required depth, and after completion are cleaned out, the cartridge inserted and tamped, the tube withdrawn, and the charge fired by electricity. In order to thoroughly break up the rock the holes were drilled five feet apart.

In September, a dredge was brought from Big Sodus, and on the 25th commenced operation upon the rock already blasted, and continued until November 8, when work ceased on account of the weather. Much time was lost on account of violent gales.

In dredging the blasted rock, it was found to be thoroughly broken up and was removed with facility, but when an attempt was made to dredge the rock without blasting, it was a failure. When the rock is covered with only a foot of sand, gravel, &c., it is not economical to dredge the superincumbent material before blasting, the cutting being so light.

Operations were resumed, drilling and blasting early in April, and dredging in the latter part of the month. The dredging was suspended May 20 for want of funds, but drilling and blasting were continued until the close of the fiscal year.

WORK DONE DURING THE YEAR.

The following has been accomplished during the fiscal year: 1,132 holes, amounting to 4,356 linear feet, drilled; 3,503 cubic yards of red shale and rock, and 1,958³³/₁₀₀ cubic yards of mud, sand, and gravel removed by dredging; one raft complete constructed.

The violent gales during the winter of 1873-74 caused the west pier to settle considerably near the outer end, but no material damage was done.

At present the west pier is 1,135 feet long and the east pier 915 feet long. With the exception of the settlement above referred to, both are in good condition. The channel between the piers, for a width of from 40 to 80 feet, presents a depth of 12 feet at ordinary low water. During the present season it is proposed to widen and deepen the channel by removing rock, &c., and to level up and repair the piers where they have settled.

The estimate for the improvement of this harbor presented in 1869 by my predecessor, the late Major Bowen, was \$137,000.

Up to the close of the fiscal year ending June 30, 1874, \$127,500 had been appropriated, of which amount \$117,432.33 had been expended.

Fifteen thousand dollars will be required to complete the project. The excess arises from the fact that since the estimate of 1869 was made a broad ledge of red sandstone rock has been found to exist, stretching across the channel between the piers, the excavation of which is much more expensive than that of ordinary material. The timber of the piers has also become decayed, and a portion of it has required renewing, which was not anticipated when the estimate of 1869 was made.

Oak Orchard is a port of entry in the collection-district of Genesee.

The nearest fort is Niagara, forty-five miles distant.

A fixed white light of the fourth order has been placed on the outer end of the west pier.

The amount of revenue collected during the fiscal year was \$2,077.34.

The value of the imports was \$14,130.

The number of vessels entering and clearing was 43, with an aggregate tonnage of 1,647 tons.

A financial statement is transmitted herewith.

Financial statement.

Balance in Treasury of United States July 1, 1873	\$10, 673 73
Amount in hands of officer and subject to his check	16 97
Amount appropriated by act approved June 23, 1874	10, 000 00
Amount expended during the fiscal year ending June 30, 1874	10, 623 06
Amount available July 1, 1874	10, 067 64
Amount required for the fiscal year ending June 30, 1876	15, 000 00

F 3.

CHARLOTTE HARBOR, NEW YORK.

HISTORY OF THE WORK.

At the first session of the Twentieth Congress, in 1828, an appropriation of \$300 was made—

For making a survey of Genesee River and Harbor, in the State of New York, and an estimate of the cost of improving the same.

In June of that year Capt. T. W. Maurice, of the Corps of Engineers, was charged with this duty, and in the following January reported the result of his survey.

The source of this river is in the northern part of Pennsylvania, from whence it flows in a northerly course across New York one hundred and fifty miles to Lake Ontario. It has six falls, amounting to 384 feet, besides numerous rapids, but is navigable for sloops from the lake nearly to the first fall, a distance of four miles. Rochester, then, as now, the principal town upon it, was a growing village of 11,000 inhabitants, and gave indications of its future importance. From the lake to the falls was a safe and commodious harbor, showing a depth of from 18 to 27 feet, but unavailable, from the fact that a sand-bar stretched nearly half a mile into the lake; through this was an intricate channel admitting, in calm weather, vessels drawing 8 feet, but so tortuous as to be unavailable in a storm. Captain Maurice proposed to construct parallel piers, 360 feet apart, which should so confine and direct the action of the spring freshets as to scour a channel through the bar. This plan was carried out with excellent success.

In accordance with these recommendations, Congress, in 1829, made an appropriation of \$10,000, and the work was at once commenced.

Annual appropriations were made in 1830, 1831, 1832, and 1833, amounting, in all, to \$61,000; and in 1833 the west pier had been carried out 2,305 feet and the east pier 2,407 feet. The effect thus far had been to produce a channel 11 feet deep—it having changed from 4 to 16 feet in some places. It was then recommended that a still further improvement be made, by prolonging the piers 900 feet, and so securing a uniform depth of 15 feet. It was also proposed to construct a beacon.

To carry out this project, an appropriation of \$20,000 was made in 1834, and the piers were extended to a length of 2,876 feet on each side, including a crib 40 feet square at the end of the west pier, and one 30 feet square at the end of the east pier.

As was anticipated, the extension of the piers had improved the channel, so that it presented a minimum depth of 15 feet.

In 1835 an appropriation of \$2,390 was made, and a masonry superstructure, built on the 40-foot crib, which was located 2,700 feet from the shore; upon this a masonry beacon, 25 feet high and 20 feet in diameter, was constructed, and was constantly used until its destruction in 1843.

The substitution of a masonry superstructure for the wooden one was recommended in 1836 and an appropriation of \$20,000 was made, but, on account of high water, the building of the masonry was deferred. In 1837, \$10,000 was appropriated, and in 1838 \$25,000.

The water still being high, nothing was attempted other than to level the pier, which had settled, and to receive and cut the limestone for the proposed superstructure; an appropriation of \$50,000 was asked for to complete the project.

No further appropriations were made until 1843, although repeatedly

urged, the piers in the mean time showing such evidences of decay that the proposed superstructure was absolutely necessary.

In 1842 Captain Canfield reported that through the decay of the timber, 60 feet of the ends of both piers had been carried away, and that the beacon was left isolated and greatly exposed; two breaches had occurred in the east pier, and it was probable that a large portion of the remainder might be destroyed at any time.

In 1843 \$10,000 was appropriated, and at once applied to repairing the piers. The prediction of probable damage proved correct, for the east pier was all destroyed several feet under water, in many places being quite gone, while the west pier was but little better. The beacon was either destroyed or greatly damaged, for \$6,000 was asked to construct a suitable one. It was proposed to expend the stone on hand in building two pier-heads if an appropriation of \$10,000 could be obtained. In spite of the condition of the piers, a good channel was still maintained.

Although the piers were rapidly falling into decay, no further appropriation was made until 1853, when \$20,000 was appropriated, and applied to rebuilding the west pier; the restoration of the east pier was much needed, and an appropriation was repeatedly urged.

In 1857 Colonel Graham reported the work in very bad condition, and an appropriation absolutely necessary to save the harbor. Although repeated each year, nothing was done until 1864, when an allotment of \$25,000 was made from the general appropriation for "repair and preservation of lake harbors."

Major Tardy, of the Corps of Engineers, was assigned to the charge of the work, and at once commenced operations on the repair of the west pier, and continued under this appropriation during the year 1865.

In 1866 an appropriation of \$75,607.30 was made, and in 1867 the west pier was completed, Lieutenant-Colonel Blunt having in the mean time been assigned to the charge of the harbor. The project of a masonry superstructure was abandoned, as being too expensive, and that of wooden cribs, filled with stone and surmounted by a superstructure of the same character, adopted.

Operations were continued in 1868 and 1869, rebuilding the east pier, until all of the available funds were exhausted.

At the close of 1868 Lieutenant-Colonel Blunt was relieved, and in May, 1869, Major Bowen, of the Corps of Engineers, assumed charge. The east pier was nearly finished, and in 1870 an appropriation of \$12,000 was made, which was applied to completing it and to raising the outer end of the west pier.

In January, 1871, Maj. John M. Wilson, Corps of Engineers, assumed charge of the work, and in March of that year an appropriation of \$10,000 was made, which was applied to renewing the superstructure of the west pier, where it was necessary.

At present the piers may be said to be in fair condition, but requiring repairs to the superstructure at various points. The sloping cribs placed near the outer end of the west pier, for its protection, have been badly damaged during the past winter. The channel is in good condition, showing a depth of from 12 to 16 feet at low water.

The operations during the past fiscal year have consisted only of such minor repairs as were rendered absolutely necessary, the damage having resulted from severe gales. A re-survey of the harbor was made in May, 1874, and the chart is transmitted herewith.

During the present season it is not proposed to do any work, there being no funds available.

The original estimate for putting this harbor in complete order, made in 1866, was \$85,607.30. Since that period \$97,607.30 has been appropriated and expended; \$5,000 will be required to complete repairs, replace decayed timber, plank, &c. The excess over the original estimate arises from damage by violent gales, decay of timber, and the necessity of raising the outer portions of the piers for the better protection of the entrance to the harbor.

Charlotte is a port of entry for Rochester, and is six miles north of the city.

There is a fixed white light of the fourth order on shore, and a beacon, with a fixed white light of the sixth order, on the west pier.

The revenue collected during the fiscal year was \$43,405.85; the value of imports was \$273,494; the value of exports was \$367,565; the number of vessels entering was 575, with an aggregate tonnage of 101,753 tons; the number of vessels clearing was 569, with an aggregate tonnage of 106,464 tons.

There has been received at this port, coastwise, during the year, 17,726 tons of iron-ore and 5,092 tons of limestone, and there has been shipped, coastwise, 9,815 tons of coal.

A financial statement is transmitted herewith.

Financial statement.

Amount expended during the fiscal year ending June 30, 1874, from appropriation for examinations, surveys, &c., act of 1870.....	\$634 32
Amount required for the fiscal year ending June 30, 1876.....	5,000 00

F 4.

PULTNEYVILLE HARBOR, NEW YORK.

HISTORY OF THE WORK.

In 1828 Congress made an appropriation of \$400—

For making a survey and examination of the southern shore of Lake Ontario, between Genesee and Oswego rivers, with a view to the improvement of the most accessible and commodious harbors on the frontier and an estimate of the cost of same.

Capt. Theo. W. Maurice, Corps of Engineers, was ordered upon this duty, and in October of the same year the survey was commenced. In a preliminary examination of the coast Pultneyville Bay was decided to be of secondary importance, and its survey was deferred until the others were completed. It was made late in the fall, and a map and report presented in January, 1829. The bay was described as being an indentation of the shore of the lake, nineteen miles east of Genesee and ten miles west of Big Sodus. This was protected from the southwest by a projecting point, but was exposed to winds from the west around to the north and east. It could not therefore be considered a safe roadstead, though its anchorage was good.

The village of Pultneyville was situated directly upon the bay, and the citizens had already expended large sums for the improvement of their harbor. Salmon Creek empties into the lake at this locality, but had not sufficient volume to be efficient in scouring a channel, and the plan was therefore made independent of it. This plan consisted of a system of piers inclosing a portion of the lake in front of the village and leaving an entrance 150 feet wide. The estimated cost was \$30,896.

No appropriation was made, however, and nothing further done until 1846, when a resurvey, with a like result, was made under Major Turnbull. Meanwhile the inhabitants had expended about \$30,000 upon the harbor, and had built several short cribs and a long wharf jutting boldly out into the lake, but giving no shelter when the wind was on shore.

In 1867 another survey was made under direction of Lieutenant-Colonel Blunt, Corps of Engineers, by whom a plan was submitted. The great improvements made in dredging-machines caused Colonel Blunt to submit a new project; and instead of building an outer harbor it was proposed to obtain shelter by dredging the creek, and to gain access to this by building two parallel piers from the shore to the deep waters of the lake. The estimated cost was \$87,000.

In 1870 an appropriation of \$5,000 was made for this work, and in the mean time the charge of it had passed into the hands of Major Bowen. The plan proposed by him, and which was approved, and is now being carried out, differed somewhat from the preceding ones, and consisted of a pier running east from the west shore 180 feet; thence north into the lake 290 feet, with an east pier parallel and 200 feet from the long arm of the west pier. It was proposed to dredge the harbor so formed, and also the channel of the creek.

In January, 1871, Maj. J. M. Wilson, Corps of Engineers, assumed charge of the work. In March an additional appropriation of \$5,000 was made, and, during the season of 1871, 180 feet of the west pier was constructed. In 1872 an appropriation of \$10,000 was made, and by the close of the fiscal year ending June 30, 1873, 180 feet of the east pier had been completed.

OPERATIONS DURING THE FISCAL YEAR.

Congress having made an appropriation of \$10,000 for this harbor in March, 1873, proposals were invited for continuing the construction of the east pier, and the work of building 210 linear feet was awarded in April to Mr. C. H. Harrington. Operations were commenced in July, and by the close of November the east pier had been lengthened 212 feet, 122 feet having been added to the lake end in a depth of 10 feet water, and 90 feet to the shore end in a depth of 6 feet. The work was done promptly and well.

In the construction of this work the following materials were used :

88,217 feet, board-measure, hemlock timber.
 49,540 feet, board-measure, pine timber.
 8,210 feet, board-measure, hemlock plank.
 10,416 feet, board-measure, pine plank.
 432 feet, board-measure, oak posts.
 3,374 pounds screw and washer bolts.
 12,670 pounds drift-bolts.
 750 pounds spike.
 260 $\frac{1}{2}$ cords of stone.

In October, 1873, a re-survey of the harbor was made, and a chart showing its present condition is transmitted herewith.

At present the west pier is 180 feet long, and the east pier 392 feet long; the west pier has yet to be prolonged 290 feet into the lake, and the east pier connected with the shore a distance of 180 feet; no dredging has been done as yet, except for foundations for cribs. During the present season it is proposed to construct 110 feet of the west pier, and to open a channel between the piers, and up to the mouth of the creek.

The estimated cost of the work under the present project was \$59,000.

Up to the close of the fiscal year ending June 30, 1874, \$40,000 had

been appropriated, of which amount \$30,000 had been expended. Nine. teen thousand dollars will be required to complete the work.

Pultneyville is a port of entry in the collection-district of Genesee.

The nearest fort is Ontario, forty-five miles to the eastward, and the nearest light is at Bigodus, twelve miles distant.

The revenue collected during the last fiscal year was \$859.18 in gold.

Twenty-six vessels, with an aggregate tonnage of 886 tons, entered, and twenty-three vessels, with an aggregate tonnage of 856 tons, cleared.

An abstract of contracts in force and a financial statement are trans- mitted herewith.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$10,800 00
Amount in hands of officer and subject to his check.....	1,788 28
Amount appropriated by act approved June 23, 1874.....	10,000 00
Amount expended during the fiscal year ending June 30, 1874.....	12,588 28
Amount available July 1, 1874.....	10,000 00
Amount required for the fiscal year ending June 30, 1876.....	19,000 00

Abstract of contracts for improving harbor at Putneyville, N. Y., in force during the fiscal year ending June 30, 1874, by Maj. John M. Wilson, Corps of Engineers, United States Army.

Contractor's name and residence.	Date of contract.	Subject of contract.	Timber and plank.			Iron.			Stone, per cord.	Labor.			Remarks.	Contract closed, October 20, 1873.
			Hemlock, per 1,000 feet board-measure.	Pine, per 1,000 feet board-measure.	Oak snubbing-posts, per 1,000 feet board-measure.	Screw and washer bolts, per pound.	Drift-bolts, per pound.	Spikes, per pound.		Dredging, per cubic yard, in position.	Timber-work, per 1,000 feet board-measure.	Iron-work, per pound.		
Charles A. Harrington, Albion, N. Y.	1873. May 16	Materials and labor	\$33 00	\$42 00	\$50 00	\$0 10	\$0 09	\$0 08	\$3 00	\$1 50	*	*		

* The prices of materials include the cost of all labor, &c., necessary to complete the pier-work with those materials.

F 5.

GREAT SODUS HARBOR, NEW YORK.

HISTORY OF THE WORK.

In June, 1828, in accordance with an act of Congress, Capt. Theo. W. Maurice, of the Corps of Engineers, was ordered by the Engineer Department to make an examination and survey of the southern shore of Lake Ontario, between the Genesee and Oswego Rivers, with a view to the improvement of the most accessible and commodious harbors on the frontier.

A preliminary reconnoissance in October resulted in the selection of Great Sodus Bay as the one point of primary importance in a commercial and military point of view within these limits.

The entrance to the bay was at this time closed to vessels drawing more than 8 feet by a bar that stretched entirely across a distance of 1,150 yards.

Captain Maurice presented a plan of improvement, consisting of two breakwaters, one about 2,200 feet long, running nearly east from the west shore, and the other about 1,400 feet long, running nearly west from the east shore, the outer ends to be 500 feet apart; from these outer ends two parallel piers to define the entrance were to run out into the lake in a direction nearly north.

It was expected that the reflux action of the water driven in by northerly gales would clear the channel and keep it open, but this expectation was not realized, and the use of dredges was found necessary.

In 1829 Congress made an appropriation of \$12,500, and work was at once commenced.

Additional appropriations were made in 1830, 1831, 1832, and 1833, amounting in all to \$64,730, and the progress of the work was such that in 1833 the breakwaters along the crown of the bar on each side were completed, as well as 640 feet of the west and 80 feet of the east channel pier; a jetty 150 feet long from the angle of the east pier southeasterly was also built.

The effect of the work had been to increase the depth on the bar from less than 8 to 9 feet, but the remainder of the obstructions being a concretion of sand and iron of considerable hardness, it was found that it would be necessary to remove it by dredges, the cost of which operation, including the purchase of machinery, was estimated at \$20,000, for which it was thought that a channel 1,500 feet long, 150 feet wide, and 15 feet deep could be obtained.

In 1834 an additional appropriation of \$15,000 was made, and the piers were reported to be nearly completed, including 300 feet of crib-work protection at the Charles Point Isthmus, the abrasion of which, during the then existing high water, threatened to open a passage east of the point.

In 1835 an appropriation of \$11,790 was made, and, the piers being completed, dredging was commenced on the proposed channel. A masonry beacon was also commenced at the extremity of the west pier. This beacon was completed in 1836 and continued in use until 1857, when it was destroyed, the pier-head being decayed.

In 1836 an appropriation of \$12,600 was made, and at the close of that season half the channel was reported to have a depth of 14 feet at low water. This evidently meant half the proposed width of the channel, for in October, 1838, Captain Smith reported that at the close of

1837 the deep waters of the lake and bay were connected by a channel 100 feet wide, and urged further appropriations in order that it might be enlarged to a useful width. Twelve thousand dollars was appropriated in 1837 and devoted to dredging, and \$10,000 appropriated in 1838 was used for the same purpose.

Portions of the piers above water had become much decayed, and the construction of a masonry superstructure was urged, the estimate of the cost of which, together with an addition of 45 feet to the width of the channel, was \$50,000.

Although the necessities of the harbor were repeatedly urged, no further appropriations were made until 1844, when \$5,000 was appropriated and applied in 1845 to the repairs of the west-channel pier, which was in the worst condition. A survey made at this time showed a depth of only 9 feet in the channel, and dredging was again recommended. Nothing was done, however, and in 1848 a survey showed a depth of only 8 feet, the same that existed before operations were commenced.

In 1852 an appropriation of \$10,000 was made, and applied by Major Turnbull to the partial repair of the channel piers. Nothing further was done until 1866, the charge of the work in the mean time having passed through the hands of Col. J. D. Graham to Lieutenant-Colonel Blunt.

An appropriation of \$53,151.80 was made in 1866, and during the years 1867, 1868, and 1869 operations were carried on under it, restoring the channel piers and dredging between them.

In May, 1869, Major Bowen assumed charge of the work, and at the close of that season the west-channel pier and part of the east were reported repaired, and a channel 200 feet wide and 10 feet deep completed.

In 1871 the work was transferred to Maj. J. M. Wilson, but no appropriation granted until 1872, when \$15,000 was appropriated.

A resurvey showed that the channel had again filled up in places, showing a depth of only $7\frac{1}{2}$ feet water. The east breakwater was in a very dilapidated condition, more than half of it having been destroyed. Operations were resumed in 1872, dredging the channel between the piers and repairing the east breakwater, and by the close of the fiscal year ending June 30, 1873, 433 feet of the breakwater had been rebuilt, and a channel 200 feet wide and 10 feet deep nearly completed.

• OPERATIONS DURING THE FISCAL YEAR.

The opening of the fiscal year found operations in progress, dredging a channel 200 feet wide under contract with E. H. French.

This contract required the removal of 29,596 cubic yards, measured in position, and that a channel 1,700 feet long, 200 feet wide, and 10 feet deep at low water, should be dredged. The work was well advanced on July 1, and by September 21, 1873, was completed, and a clear channel of that width and depth existed between the piers. In dredging this 29,596 cubic yards, measured in position, the contractor removed 41,600 cubic yards measured in scows, a gain of about 40 per cent. A portion of this gain arose from the fact that the cuts were made too far apart, thus leaving ridges, from which, in going over again, more material was taken out than was absolutely necessary.

One hundred and fifty-eight feet of the east breakwater, which remained to be decked over at the close of the last fiscal year, was completed by August 10.

No appropriation having been made for the fiscal year, operations were suspended for want of funds in September, 1873.

At present the channel is 200 feet wide, and presents a depth of 10 feet at low water; it should be dredged out entirely between the piers, otherwise there will be continual trouble, arising from the shifting sand that constantly slides into the portion already dredged. The west pier is in good condition; the superstructure of the east pier for a distance of 425 feet requires to be renewed, and the east breakwater requires rebuilding for a distance of 500 feet.

It is very necessary, in order to properly complete this project, that the east breakwater should be connected with Charles Point, but the owner of the land there objects to the connection being made.

During the present season it is proposed to remove 45,000 cubic yards of sand, gravel, &c., from between the piers, and to repair about 350 linear feet of the east breakwater.

The estimates made for renewing the piers and dredging the channel, as reported in 1868 and 1869, called for \$118,000.

Up to the close of the fiscal year ending June 30, 1874, \$93,181.80 had been appropriated, of which amount \$78,181.80 had been expended. Twenty thousand dollars will be required to complete the work.

A large amount of superstructure now requires to be renewed, which was in good order when the estimate was made.

Big Sodus is a port of entry in the collection-district of Oswego. There is a fixed white light, varied by flashes, of the fourth order, at this place, and two beacon-lights as ranges on the piers.

Port Ontario is the nearest work of defense.

The amount of revenue collected at this port during the fiscal year was \$355.30.

The value of the imports was \$3,256. The value of the exports was \$40,144.

Sixty-one vessels, with an aggregate tonnage of 3,721 tons, entered, and sixty-three vessels, with an aggregate tonnage of 3,867 tons, cleared during the year.

An abstract of contracts in force and a financial statement are transmitted herewith.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$55 84
Amount in hands of officer and subject to his check, (including \$666.32, percentage due on contracts not yet completed).....	4,694 40
Amount appropriated by act approved June 23, 1874.....	15,000 00
Amount expended during the fiscal year ending June 30, 1874.....	4,694 40
Amount available July 1, 1874.....	15,055 84
Amount required for the fiscal year ending June 30, 1876.....	20,000 00

Abstract of contracts for improving harbor at Big Sodus, N. Y., in force during the fiscal year ending June 30, 1874, by Maj. John M. Wilson, Corps of Engineers, United States Army.

Contractor's name and residence.	Date of contract.	Subject of contract.	Dredging between the piers, per cubic yard, in position.	Remarks.
E. H. French, Fulton, N. Y.	Aug. 28, 1873	Dredging ...	\$0 35	Contract closed August 20, 1873.

F 6.

LITTLE SODUS HARBOR, NEW YORK.

HISTORY OF THE WORK.

The first survey of this harbor under the General Government was made in the fall of 1828, in accordance with an act of Congress, direct-

ing an examination of the harbors on the southern shore of Lake Ontario, between the Genesee and Oswego Rivers.

The work was done under the supervision of Capt. Theo. W. Maurice, of the Corps of Engineers, who submitted a report in January, 1829. Although the harbor was at that time deemed one of secondary importance, its improvement was recommended and a plan submitted.

The entrance to the bay was closed, except through two narrow openings by a beach of gravel standing well out of water.

The plan proposed was to close one of these openings by a dike 130 yards long, and at the other to run out two parallel piers in a direction nearly due north, the piers to be each 290 yards long. The estimated cost was \$32,327.59.

It was presumed that the reflux action of the water, driven in during storms, would be sufficient to clear out the channel and keep it open.

No appropriation was made, however, nor any further action taken until 1845, when a re-survey was made under the direction of Major Turnbull, of the Corps of Topographical Engineers; this survey showed the condition of the harbor to be about the same as in 1828.

In 1852 Congress made an appropriation of \$10,000 for this harbor, but in the mean time, since 1845, the gravelly beach which had crossed the entrance, and had formed a part of the plan for improvement, had been swept away, and a new project was necessary.

A re-survey was made, and in 1853 it was determined to adhere to the original piers as designed, and to connect their inner ends with the adjacent shores by riprap.

Work was commenced in 1854, and 240 feet of the west pier was built and the west riprap formed. Shingle accumulated rapidly around the riprap, and by the close of the season a beach from 10 to 50 feet wide and 600 feet long was formed; a channel 6 feet deep at low water was also dredged. Twenty-five thousand two hundred and nine dollars was asked for the next season.

In 1856 work was suspended for want of funds; the result thus far had been very gratifying, the channel having been deepened and shingle having accumulated around the riprap.

In 1857 Lieutenant-Colonel Graham reported that, in order to complete the project and carry out the piers to 15 feet water, the construction of an east pier 832 feet long, and an addition of 608 feet to the west pier was necessary; the estimated cost of these, together with the required dredging, was \$52,602.

In 1858, the people locally interested formed a company known as the "Ontario Bay Harbor Improvement Company." It proposed to aid the General Government in improving the harbor, and had on hand \$6,000 in money and materials with which to build, under the supervision of the engineer officer in charge, 300 feet of pier. It is presumed that this was carried out, for in 1866, 284 feet of pier was still in existence, although a portion of the outer ends had evidently been carried away.

Although the estimate of 1857 was presented each succeeding year, no further action was taken by Congress until 1866, when an appropriation of \$33,840.41 was made, and the work placed in charge of Lieutenant-Colonel Blunt, of the Corps of Engineers.

The survey made in the fall of this year showed a depth of $5\frac{1}{2}$ feet at low water in the channel.

Lieutenant-Colonel Blunt proposed to extend the west pier out to a depth of twelve feet at low water, to connect it with the west shore by riprap or otherwise, to dredge a channel four hundred feet wide, the inner end on the east side to be connected with the east shore by a riprap;

he deemed an east pier unnecessary; \$80,000 was asked to complete the project.

In 1867 an appropriation of \$50,000 was made, and operations were commenced early that season, and continued under these appropriations through 1867 and 1868.

At the close of 1868 the west pier, 800 feet long, was completed, and 650 linear feet of triangular crib work had been constructed, connecting the inner end of the west pier with the west shore. A channel 200 feet wide, and varying from 8 to 15 feet deep, had been dredged parallel to the pier. A short east pier was found to be necessary, and \$25,000 was asked for the next season.

Lieutenant-Colonel Blunt was relieved in January, 1869, and Major Bowen assumed charge in May of that year.

An examination at that period showed that, owing to the character of the bottom and dredging too close to the pier, a portion of the crib-work had settled considerably toward the channel; the triangular crib-work connecting with the west shore had been breached during the winter, and its replacement by a stronger work was necessary.

The cost of repairing and leveling the west pier, and the breakwater connecting it with the west shore, was estimated at \$25,000.

By June, 1870, the west pier had been extended 120 feet, and 445 feet of the inner portion had been leveled and repaired; the breakwater connecting with the west shore had been temporarily repaired, but a new one was necessary.

In July, 1870, an appropriation of \$5,000 was made, and operations were continued on the releveling and repairing the west pier, and the construction of the new breakwater was commenced. By December of that year 256 feet of the pier had been repaired, and 200 feet of the new breakwater had been sunk. The effect of the old breakwater, built in 1868, had been excellent except where breached, and a beach had formed 100 feet wide in some places.

Maj. John M. Wilson assumed charge of the work in January, 1871, and in March of that year an appropriation of \$15,000 was made.

A survey of the harbor in August, 1870, showed a channel varying from 75 to 150 feet in width and from 8 to 15 feet deep.

During the year 1871, 350 feet of the west pier was leveled and repaired, a crib 30 feet square for a beacon was sunk at the outer end of the pier, the new breakwater connecting the pier with the west shore was completed by constructing 269 feet of crib-work and superstructure, and the channel over the bar was widened to 200 feet, and deepened throughout its whole extent to 12 feet at low water. A shoal discovered inside the harbor, which had been caused by the breach through the old breakwater, was also removed.

In 1872 an appropriation of \$15,000 was made, and the construction of the east pier was commenced in September of that year; a beacon was also placed at the outer end of the west pier.

A survey of the harbor in May showed but little variation in the depth and width of the channel from that at the close of 1871.

By the end of the season of 1872 the cribs, for 270 feet of the east pier, had been placed in position, and by the close of the fiscal year ending June 30, 1873, 210 feet of the superstructure upon these cribs had been completed.

In March, 1873, an appropriation of \$15,000 was made, and it was determined with this to extend the east pier 120 feet in a northerly direction, and to construct a portion of the breakwater connecting its inner end with the east shore.

OPERATIONS DURING THE FISCAL YEAR 1873-'74.

The opening of the fiscal year found operations in progress, under contract with H. J. Mowry, completing the 390 feet of the east pier commenced in the fall of 1872, and with T. B. Hart, continuing the construction of the east pier and commencing the east breakwater.

Operations were continued until the last of August, when they were suspended for want of funds. During this period a canal, 30 feet wide and 245 feet long, was dredged for the foundation of the east pier; 243 feet of pier complete and 60 feet of superstructure upon cribs previously sunk were added to the east pier, which is now complete with the exception of 100 cords of stone yet necessary to entirely fill it.

The east breakwater was commenced in July, and during the season 240 feet of crib-work was sunk, the superstructure entirely completed to its full height on 110 linear feet, and within one foot of the full height on the remainder. The west pier was also repaired in many places.

The following work has therefore been accomplished during the year: 243 feet of crib-work complete, sunk in 10 feet water.

60 feet of superstructure built on cribs sunk previously.

110 feet of the east breakwater entirely completed.

130 feet of the east breakwater completed, except one course of timber.

The decking of the west pier repaired in many places.

In the performance of this work the following materials have been used:

154,647½ feet, board-measure, hemlock timber.

6,552 feet, board-measure, hemlock plank.

144,211½ feet, board-measure, pine timber.

42,887 feet, board-measure, pine plank.

77 linear feet of oak posts.

6,796 pounds of screw and washer bolts.

25,100 pounds of drift-bolts.

2,601 pounds of spikes.

523.84 cords of stone.

The present condition of the harbor is as follows:

Both piers have been carried out as far as is necessary for the present; the east pier requires about 100 cords of stone to complete the filling; the west pier requires new decking upon about 600 feet of its length. The channel between the piers is in good condition, presenting a depth of from 10 to 14 feet at low water, except near outer end of the west pier, where a small shoal has formed, caused by the action of the sea around it.

The west breakwater is in good condition, as is also the east, as far as it has been built; 1,500 feet of the latter is yet to be constructed in order to connect it with the east shore.

During the present season it is proposed to renew the decking on the west pier, to complete the filling of the east pier, and to add about 540 linear feet to the east breakwater.

If it is found to be necessary, the shoal around the outer end of the west pier will be removed by dredging, but if possible this will be postponed until next season.

Little Sodus is a port of entry in the collection-district of Oswego; it is now the terminus of the Southern Central Railroad, and large quantities of coal are shipped from this place.

Fort Ontario, fifteen miles distant, is the nearest work of defense.

A fixed white light of the fourth order has been placed on the outer end of the west pier.

The amount of revenue collected during the fiscal year was \$2,227.36.

The value of the imports was \$15,040.75; the value of the exports was \$470,840. Among the exports were 70,000 tons of coal and 1,430 tons of pig-iron.

Two hundred and seventy-two vessels entered and cleared during the year.

The original estimate for the completion of the present project was \$176,000, which included the rebuilding of, and prolonging, the west pier, rebuilding the west breakwater, building an east pier and an east breakwater, and dredging the channel.

Up to the close of the fiscal year ending June 30, 1874, \$148,840.41 had been appropriated, of which amount \$133,840.41 had been expended.

Twenty-seven thousand dollars will be required to complete the project, which now includes the removal of a sand-bar recently formed off the outer end of the west pier.

Abstract of contracts in force and financial statement are transmitted herewith.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$15,555 33
Amount in hands of officer and subject to his check, (including \$627.89 percentage due on contracts not yet completed).....	4,917 15
Amount appropriated by act approved June 23, 1874.....	15,000 00
Amount expended during the fiscal year ending June 30, 1874.....	20,417 15
Amount available July 1, 1874.....	15,055 33
Amount required for the fiscal year ending June 30, 1876.....	27,000 00

Abstract of contracts for improving harbor at Little Sodus, N. Y., in force during the fiscal year ending June 30, 1874, by Major John M. Wilson, Corps of Engineers, United States Army.

Contractor's name and residence.	Date of contract.	Subject of contract.	Timber and plank.			Iron.			Stone, per cord.			Labor.			Remarks.
			Hemlock, per 1,000 feet, board-measure.	Pine, per 1,000 feet, board-measure.	Snubbing-posts.	Screw and washer bolts, per pound.	Drift-bolts, per pound.	Spikes, per pound.				Dredging, per cubic yard.	Timber-work, per 1,000 feet, board-measure.	Iron-work, per pound.	
Henry J. Mowry, Syracuse, N. Y.	1872.	Materials and labor.	\$24 00	\$32 00	\$40 50	\$0 08	\$0 06	\$0 07	\$8 00	\$1 00	\$7 00	\$1 00	\$7 00	\$0 01	Contract closed July 31, 1873.
Thomas B. Heart, Oswego, N. Y.	Ang. 23 1873. May 9	do	30 00	42 00	60 00	09	09	09	7 00	d1 00	d1 00	d1 00	*	*	Contract closed August 23, 1873.

a Per linear foot.

b Per 1,000 feet, board-measure.

c Measured in saws.

d Measured in position.

* Prices of materials include all labor, &c., necessary to work materials into the pier.

F 7.

OSWEGO HARBOR, NEW YORK.

HISTORY OF THE WORK.

The earliest map on record of Oswego (then Chonagnen) was made by Chaussegas De Lery, and dated July 17, 1727.

The harbor was then formed by a low spit, which extended from the west bank of the river near its mouth and sheltered a portion of the channel within.

The next map, made in 1756, shows a similar spit extending from the east bank, narrowing the entrance and increasing somewhat the sheltered area.

In 1827 the mouth of the river was described as being an open roadstead, affording no shelter from winds off the lake. The two low sandy strips were still in existence, but the area they sheltered was small and shallow, and during the spring and fall was difficult of access, on account of the strong current.

The growth of commerce rendered a harbor necessary, and Congress made an appropriation of \$33,384.64 for that purpose, and work was at once commenced.

The plan was to inclose an area at the mouth of the river by extending jetties about 230 feet into the lake from each shore, and joining the outer ends of these, which were 2,050 feet apart, by a breakwater, leaving, however, an opening of 250 feet through which to enter the channel.

This was one of the first lake harbors commenced by the Government, only four others, Erie, Sackett's, Buffalo, and Ashtabula having received appropriations before it.

In 1828 an appropriation of \$9,583.39 was made, and in 1829 the breakwater was completed.

In February, 1829, Capt. T. W. Maurice, of the Corps of Engineers, recommended the formation of a mole outside the west pier, the cost of which, together with a pier-head, was estimated at \$12,720.

In 1830 an appropriation of \$7,472 was made and the formation of the mole commenced; counterforts were also recommended to strengthen the west pier.

In 1831 an appropriation of \$22,016.84 was made, and in 1832 one of \$19,000; the construction of the mole was continued and counterforts built to strengthen the pier.

In 1834 an appropriation of \$8,400 was made and Lieut. R. C. Smead, of the Fourth Artillery, was assigned to the charge of the work.

Lieutenant Smead reported the work on the mole as commenced, but nowhere completed; a sufficient amount of stone had been thrown in to form the desired mound if the fragments had been large enough to keep their places, but the greater part were only from 100 to 500 pounds' weight, and were moved by the waves as readily as beach-gravel; quantities of them, with sand formed by the abrasion of the rest, had been thrown over the piers by the waves and formed banks inside. During 1833 a part of the mole was raised as high as the top of the pier, (6 feet above water,) and some more of it to the water-surface.

Col. Jos. G. Totten inspected the work at this time and recommended that the mole be given a certain regular profile and then paved with flat limestone; in its present condition, he stated, was such that it only served to guide the waves against the face of the pier. Observations both here and elsewhere showed that when the depth was too great for waves to

break upon the natural bottom, a vertical wall was the best to resist them, but it was too late to apply this principle to the west pier, and the sloping profile must be perfected.

Forty-three thousand dollars was asked for this and for a pier-head, and \$5,500 for a stone light-house to be built on the proposed pier-head to replace the old one on the bluff near the fort.

An estimate of \$56,802 was also presented for a masonry superstructure for the pier, which would be needed when the wooden one was decayed.

In 1834 an appropriation of \$30,000 was made for the pier and mole, and \$3,666 for the light-house.

General Gratiot, in his annual report, stated that the appropriation for that year was made so late that the only work that could be done was to repair the damages of the winter and to add about 900 cords of stone to the mole. Lieutenant Smead reported that the portion of the mole raised 6 feet above water in 1833 was entirely washed down, and in the spring of 1834, 2 to 4 feet of water was found where it had been; the stone placed in 1834 weighed from two to four tons, but were too light.

In 1835 an appropriation of \$6,485 was made for the light-house, but nothing for the pier. The foundation for the light-house was built and stone prepared for the tower; 4,084 cords of stone and 1,115 tons of limestone pavement were added to the mole; the pavement was formed of Chaumot limestone, 2 feet thick, the blocks weighing three tons each; it extended out 30 feet from the pier, the foot of the slope being formed of blocks 10 feet long and 3 feet wide, weighing five tons.

In 1836 an appropriation of \$20,000 was made for the mole, and \$1,200 for the light-house; the latter was completed and the former was progressing well, 600 lineal feet being finished.

An estimate of \$111,942 was presented for completing the mole and for a masonry superstructure.

In 1837 an appropriation of \$15,000 was made, the construction of the mole continued, and that of the masonry superstructure commenced.

In 1838 an appropriation of \$46,067 was made, the portion of the masonry superstructure which was commenced in 1837 was completed, and the piers and mole thoroughly repaired; the removal of a shoal in the channel was recommended. Mr. J. W. Judson relieved Lieutenant Smead during this year. He recommended that the further construction of the mole should be discontinued, and the stone on hand applied to building the superstructure. This was approved, and work the succeeding season was carried on accordingly. A point was established 7.79 feet below the edge of limestone pavement, 61 feet north from its south end, which was intended to be at the lowest water-level of the lake. All observations of water-level have since been referred to this bench-mark; the water has several times been at it, but never below it.

No further appropriation was made until 1844. In 1839 a survey of Oswego Harbor and its vicinity was made by Captain Canfield. This survey shows a depth of 20 feet at low water, between the piers, about the same as at present, (1874,) but a marked difference has taken place outside the west pier, the present depth (1874) being only 12 feet, where it was then (1839) 24 feet. This is due partly to the material of which the mole was built, but mainly to the sand which has collected around it.

In 1841 and 1842 the reports show that the piers and mole had been

badly damaged by the gales, and that \$168,000 was required to complete the work.

In 1844 an appropriation of \$20,000 was made, and work at once commenced. Both pier-heads were rebuilt from the water-line, and the face of the piers repaired. Work was continued through 1845, and 155 feet added to the masonry superstructure of the west pier.

In 1846 all work upon rivers and harbors was suspended, the policy of Congress being opposed to internal improvements by the General Government. Mr. Judson, in his report, stated that in November and December 160 feet of the east pier was carried away, with its pier-head and counterfort.

No funds were on hand, but a sufficient sum was subscribed by the citizens for the agent to repair the remainder and secure it.

In 1847 a gravel-bar, which had formed at the foot of the "island" across the channel, was removed at private expense.

No further appropriation was made until 1852, when \$40,000 was appropriated.

In the mean time the wooden superstructure of both piers had fallen into decay, and the west pier had been badly breached.

Operations were resumed early in 1853, and during the years 1853, 1854, and 1855 were continued upon repairs of the piers. In 1853 a board of engineers, consisting of Lieutenant-Colonel Kearney and Majors Long, Bache, and Turnbull, submitted a plan for the enlargement of the harbor.

The plan was to construct two detached breakwaters, 700 feet in advance of and parallel to the original work, and 400 feet apart. These were afterward to be connected with the shores, or joined together if experience should show either to be desirable. The plan was not carried out.

In 1855 the breach made in 1852 had been fully repaired, but 420 feet of the west pier was yet to be rebuilt. The east pier was kept in repair by private enterprise, and the United States dredge, under direction of the engineer in charge, was engaged deepening the entrance to the harbor at the expense of the city.

In 1858 an appropriation of \$10,000 was made and expended upon repairs. The work was reported by Lieut. Col. J. D. Graham as in bad condition, and still needing extensive repairs, several breaches having been made during the winter of 1857.

In 1860 an appropriation of \$30,000 was made and applied, during the years 1860, 1861, 1862, and 1863, to much-needed repairs; 800 linear feet of pier was rebuilt, and a crib-work protection thrown around the angle of the stone pier.

In 1864 an allotment of \$25,000 was made to Oswego Harbor, from the general appropriation for repair of lake harbors, and Lieutenant-Colonel Blunt was assigned to the charge of the work. Operations were carried on upon repairs during 1864 and 1865. In January, 1866, the outer end of the light-house pier was breached, and the light-house was reported in danger, and in September it was reported that the outer crib had been carried away 12 feet below water; the jetty at the angle of the stone pier was also carried away, but was replaced by another; some dredging was done during the year.

An appropriation of \$45,000 was made in 1866.

In 1867 operations were continued repairing the pier and the dredge, Congress having made an appropriation of \$60,000.

A contract was made to keep the pier in repair at \$12,000 a year, which was estimated to be about the future annual expense; a large

amount of dredging was done, and portions of the harbor opened for use which had not been available for several years.

The extension of the light-house pier 500 feet into the lake was suggested.

An appropriation of \$20,000 was made in 1868, and repairs continued under the contract of 1867; dredging was continued and a depth of 12 feet was obtained throughout nearly the whole of the west cove.

Lieutenant-Colonel Blunt was relieved in January, 1869, and the charge of the work passed through the hands of Major McAlister and Captain Harwood to Major Bowen, who assumed charge in May, 1869.

An appropriation of \$22,500 was made, and work was at once commenced upon the extension of the west pier.

Major Bowen, during this year, recommended the construction of an outer harbor.

In 1870 an appropriation of \$50,000 was made, the extension of the light-house pier was completed, and the whole of the west pier repaired.

In September, 1869, a survey of the harbor and its approaches was made, and in March, 1870, Major Bowen presented a project for an outer harbor. A board of engineers, consisting of Lieutenant-Colonel Woodruff and Majors McFarland and Bowen, was convened at Oswego on the 30th of March, and the project of Major Bowen was submitted for its consideration.

The plan consisted of a breakwater 5,800 feet long, to be located nearly parallel to the old west pier, and 1,100 feet in advance of it, thus affording a good harbor about 100 acres in extent. The estimated cost was \$1,161,682.

In January, 1871, Maj. J. M. Wilson assumed charge of the work, and soon after the opening of navigation operations were commenced under contract, repairing damages done to the old pier by the winter storms, and on July 5 the construction of the new pier was commenced, an appropriation of \$100,000 having been made; \$6,000 was also allotted from the general appropriation for repairs in 1870.

By the close of the year 1871, 640 lineal feet of the new pier had been completed.

Operations were resumed by hired labor in March, 1872, the contractor having been released by act of Congress.

During this year an appropriation of \$100,000 was made and work carried on both by contract and hired labor, so that by the close of operations in November, the pier was 1,700 feet long, the superstructure being completed on 1,100 feet of it.

The old pier was also put in complete repair during the season.

The winter gales of 1872-'73 were very severe, and did considerable damage to the pier, settling it from 2 to 4 feet throughout a length of about 700 feet; the cribs of the outer 140 feet were torn from their grillage bottoms and thrown on shore. The old pier also sustained considerable damage.

In February, 1873, a survey was made through the ice on part of the line; floating ice 25 feet thick was bored through in order to determine the formation of the bottom.

Operations were resumed in April, 1873, the cribs on shore were launched, the pier leveled, crib-tops sunk, and superstructure built on the portions which had settled, and by the close of the fiscal year ending June 30, 1873, the new pier was 1,815 feet long, the superstructure upon which was completed for a length of 1,180 feet.

OPERATIONS DURING THE FISCAL YEAR.

The opening of the fiscal year found operations in progress, both by contract and hired labor; under the former they were suspended the last of August, but were continued by hired labor both on the new and old piers throughout the season.

THE NEW BREAKWATER.

The work upon the new breakwater has progressed very satisfactorily; 400 feet of crib-work has been added to the line, and three counterforts, each 30 feet long, sunk in rear of it; 1,125 feet of superstructure complete has been built, so that at the close of the fiscal year ending June 30, 1874, the new breakwater was 2,215 feet long, and strengthened by three counterforts, amounting to 90 feet more.

During the winter of 1873-'74 the pier was subjected to a series of gales of terrific violence; the damage was, however, trifling, and consisted principally in tearing off a few deck-plank, settling the stone somewhat on the lake side, the pier slightly in three places, and breaking off one snubbing-post; the violence of the sea can be somewhat appreciated when it is stated that this snubbing-post was of solid oak, 14 inches square, its top about 4 feet above the deck of the pier; it was broken off flush with the deck. By the close of the fiscal year these damages, except a small amount of stone-filling and replacing a few deck-plank, were repaired.

During the year's operations the following materials have been used on the new breakwater:

904,804 feet, board-measure, hemlock timber.
 17,378 feet, board-measure, hemlock plank.
 528,532 feet, board-measure, pine timber.
 114,021 feet, board-measure, pine plank.
 312 feet, board-measure, pine boards.
 5,060 feet, board-measure, hard-wood plank.
 4,192 treenails.
 2,265 pounds of screw and washer bolts.
 153,396 pounds of drift-bolts.
 13,223 pounds of spikes.
 5,122 cords of stone.
 192 lineal feet of oak posts.

The breakwater now forms an excellent protection from gales coming from the southwest, west, and northwest; docks are in process of construction in rear of it, which will be used this season.

The cost thus far has been about as follows: For the first 600 linear feet, the depth running from zero to 19 feet, \$70 per linear foot; for the next 1,705 feet, the depth running from 20 to 28 feet, \$159 per linear foot; the original estimate was \$200 per foot for the whole work; the deepest portion is completed.

REPAIR OF THE OLD WEST PIER.

During the fiscal year the old west pier has been most seriously damaged, and during the spring of 1874 it was literally torn to pieces, breaches amounting to 140 feet in length having been made entirely through at various points, while the outer section of the pier for a total length of 410 feet was entirely destroyed; there being but little ice, the pier was subjected to the full force of a series of most violent storms.

Minor repairs were made from time to time, when rendered necessary,

during the fall of 1873, and at the close of the working season of that year the old pier was in comparatively good order.

The opening of navigation in 1874, however, showed the pier to be a perfect wreck as previously described, and operations were commenced upon its repair in the latter part of April. By the close of the fiscal year the largest breach, 100 feet long, was closed, all the minor ones repaired, and the outer sections renewed upon 250 linear feet of the portion that was destroyed.

Much work is still to be done upon the old pier, but it is anticipated that the repairs will be entirely completed by August, 1874.

In the repair of the old pier the following materials have been used:

135,682 feet, board-measure, of hemlock timber.
 4,759 feet, board-measure, hemlock plank.
 19,837 feet, board-measure, pine timber.
 10,957 feet, board-measure, pine plank.
 135 treenails.
 929 pounds of screw and washer bolts.
 17,298 pounds of drift-bolts.
 1,181 pounds of spike.
 138.6 cords of stone.

During the present season it is proposed to complete the repairs of the old pier, and to add about 520 linear feet to the new pier, 460 feet to be upon the prolongation of the present line of the pier, and 60 feet in rear as counterforts. The work will be done by hired labor and purchase of materials in open market; agreements have already been made for materials at prices 20 per cent. less than under last contract for hemlock timber and iron, 12 per cent. less for pine timber, and 30 per cent. less for stone; the work will be pushed forward rapidly.

The original estimate for the new breakwater was \$1,161,682; up to the close of the fiscal year ending June 30, 1874, \$425,000 had been appropriated, of which amount \$349,650.96 had been expended, about \$12,000 of which has been used upon the repairs of the old pier. About \$700,000 will be required to complete the work.

Fort Ontario is situated here. There is a light-house, exhibiting a fixed white light, of the third order, and a beacon on the other end of the pier showing a fixed red light of the fourth order.

The amount of revenue collected at this port during the fiscal year was \$765,992.67; the value of the imports was \$7,356,646; the value of the exports was \$260,876. Three thousand and eighty-four vessels, with an aggregate tonnage of 547,061 tons, entered, and 3,527 vessels, with an aggregate tonnage of 577,700 tons, cleared.

An abstract of contracts in force and a financial statement are transmitted herewith.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$107, 156 24
Amount in hands of officer and subject to his check.....	5, 350 14
Amount appropriated by act approved June 23, 1874.....	75, 000 00
Amount expended during the fiscal year ending June 30, 1874.....	112, 157 34
Amount available July 1, 1874.....	75, 349 04
Amount required for the fiscal year ending June 30, 1876.....	300, 000 00

Abstract of contracts for improving harbor at Charvo, N. Y., in force during the fiscal year ending June 30, 1874, by Maj. John M. Wilson, Corps of Engineers, United States Army.

Name and residence of contractor.	Date of contract.	Subject of contract.	Timber and plank.			Iron.			Tree-nails.	Stone.	Labor.		Remarks.	Contract closed September 2, 1873.
			Hemlock, per 1,000 feet, board-measure.	Pine, per 1,000 feet, board-measure.	Oak snubbing-posts, per linear foot.	Screw and washer bolts, per pound.	Drift-bolts, per pound.	Spikes, per pound.			Per hundred, including driving.	Per cord.			Timber-work per 1,000 feet, board-measure.	Iron-work, per pound.
Henry J. Mowry, Syracuse, N. Y.	Aug. 30, 1872	Material and labor.	\$21 00	\$28 00	\$0 50	\$0 08	\$0 06	\$0 07	\$10 00	\$7 00	\$8 00	\$0 03		

F 8.

MOUTH OF BLACK RIVER, NEW YORK.

The history of this work, from its inauguration in 1836 up to the 30th of June, 1873, was given in the last annual report.

By the act of Congress approved March 3, 1873, an appropriation of \$5,000 was made for the removal of the bar at the mouth of Black River, New York. As this bar is generally affected more or less by the spring freshets it was determined to take no action until they were over. Accordingly, on June 10, Mr. W. P. Judson was ordered with a party to this locality, and directed to make a complete survey of the bar and the river and bay in the vicinity; this was accomplished by June 30.

In June proposals were invited for dredging 11,500 cubic yards of mud, sand, &c., and at the opening of bids July 16, 1873, the work was awarded to Mr. C. Daly, of Ogdensburg, N. Y. The object in view was to open a channel about 25 feet wide and 6 feet deep through the bar for temporary relief, although, as stated in the last annual report, it was anticipated that it would soon fill up again; the language of the law making the appropriation was so specific, that the engineer in charge felt as if he had no authority other than to at once do the best he could with the funds available.

Operations were commenced August 8, and by the 28th a cut had been made through the bar 3,000 feet long, 20 feet wide, and 7 feet deep, at low water; this was personally examined by the engineer in charge, and by his direction the cut was widened to 35 feet, and operations suspended for want of funds, September 17, 1873, 11,500 cubic yards having been removed.

The bar is composed mainly of silicious sand, the up-stream portion being coarse, with a specific gravity of 1.693; the middle, a degree finer—specific gravity, 1.8; the outer, very fine—specific gravity, 1.963; on this sand there rests a large quantity of water, soaked shavings, and sawdust—the specific gravity of which is 1.063.

It was observed while dredging that the sand rapidly flowed into the excavation, and was aided in this by westerly winds; the sawdust was very easily moved; and on the 15th of September, during a westerly gale, an island was formed, standing about two feet out of the water, starting from a point about 100 yards off Catfish Point, and running north-west for nearly 1,000 yards. This was so compact that men walked upon it, and it was estimated to contain about 40,000 cubic yards of sand, sawdust, shavings, &c.; in two days it was all scattered. After operations were suspended there was a strong westerly gale for three days, and at the end of that time a resurvey was made of the bar, when it was found that the cut had filled up very much, and in some parts of it there was scarcely any evidence that dredging had been done.

The system of piers mentioned in the annual report for the last fiscal year is deemed absolutely necessary, if it is proposed to improve the mouth of Black River, as it is deemed impossible to keep the channel open without them.

Dexter, just above the mouth of the river, is a port of entry in the collection-district of Cape Vincent.

The estimated cost of the improvement of this harbor, under the plan submitted, is \$214,000. Since the commencement of operations \$5,000, the entire amount appropriated, has been expended.

The amount of revenue collected during the fiscal year was \$700; the value of the imports was \$35,950; the value of the exports was \$1,500.

Two hundred and fifty-four vessels, with an aggregate tonnage of 6,500 tons, entered and cleared during the year.

Abstracts of proposals and contracts and a financial statement are transmitted.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$4,600 00
Deduct this sum expended in last fiscal year.....	24 29
Amount expended during the fiscal year ending June 30, 1874	4,575 71
Amount required for the fiscal year ending June 30, 1876, if it is proposed to carry on the work.....	50,000 00

Abstract of proposals for dredging at mouth of Black River, New York, opened by Maj. John M. Wilson, Corps of Engineers, July 16, 1873.

No.	Names of bidders.	Residence.	Price per cubic yard, measured in scows, (15,000 cubic y'ds, more or less.)	Amount.
1	Cornelius Daly.....	Ogdensburgh, N. Y.....	35 cents	* \$5,250 00
2	Henry J. Mowry.....	Syracuse, N. Y.....	36 cents.....	5,400 00

* Awarded.

Abstract of contracts for improving harbor at mouth of Black River, New York, in force during the fiscal year ending June 30, 1874, by Maj. John M. Wilson, Corps of Engineers, United States Army.

Name and residence of contractor.	Date of contract.	Subject of contract.	Per cubic yard, measured in scows.
Cornelius Daly, Ogdensburgh, N. Y.....	* July 23, 1873	Dredging	35 cents.

* Contract closed September 20, 1873.

F 9.

OGDENSBURGH HARBOR, NEW YORK.

HISTORY OF THE WORK.

The first survey of this harbor by the General Government was made in 1855, under direction of Major Turnbull, of the Corps of Topographical Engineers, but no appropriation having been made no plan of improvement was presented.

By the act of Congress approved June 23, 1866, an examination and survey was ordered, and in July the work was placed in charge of Capt. C. B. Reese, Corps of Engineers, under whom a survey was made and a plan of improvement submitted.

In the spring of 1867 Lieutenant-Colonel Blunt being in charge of the work, an appropriation of \$40,000 was made by Congress, and in June of that year a board of engineers was convened for the purpose of considering and reporting a plan for the improvement of the harbor.

The board decided that for the present the improvement should be confined to dredging selected channels, removing bowlders, &c., and that there should be no resort to piers until it was shown that the dredged channels would not be permanent.

The recommendation of the board having been approved, proposals

were invited and a contract made in August, 1867; operations were commenced in the latter part of September, and about 12,000 cubic yards removed from the St. Lawrence Channel, near the custom-house wharf. The contractor complained that he had misunderstood the character of the materials to be removed, and consequently abandoned the work.

In May, 1868, another board of engineers was convened to devise a plan for the improvement of the harbor. This board, after a careful examination of the subject, decided that the work to be done should consist of—

First. Deepening the channel over the outer bar.

Second. Deepening the water by dredging at the wharves of the Northern Railroad and Northern Transportation Company.

Third. Dredging the channel of the Oswegatchie River below the bridge.

Fourth. The excavation of a continuous channel 150 feet wide and 12 feet deep at low water, along the river front of the city, connecting the mouth of the Oswegatchie with the deep waters of the St. Lawrence, and the construction of a concave pier to maintain this channel, if it proved to be necessary.

In reference to dredging at the wharves of the Northern Railroad Company and Northern Transportation Company, the board, while admitting its absolute necessity, decided that it should be done by the wharf-owners, rather than by the General Government. This project having been approved contracts were made in September, 1868, and a channel dredged through the bar near the light-house, 300 feet wide and 14 feet deep, and considerable progress made in dredging at the mouth of the Oswegatchie.

Lieutenant-Colonel Blunt was relieved in January, 1869, and in May of that year Major Bowen assumed charge. Operations were continued during the year 1869, dredging the Oswegatchie River between its mouth and the bridge; the work here was exceedingly difficult, the bottom consisting of bowlders, rock, and hard pan. An appropriation of \$15,000 was made in 1870 and operations were continued, dredging at the mouth of the Oswegatchie, and work was commenced on the channel connecting that river with the deep waters of the St. Lawrence. In January, 1871, Major Bowen was relieved by Major Wilson, of the Corps of Engineers. In April, operations were resumed, dredging the channel in the St. Lawrence River, parallel to the line of docks, and the work has been continued from time to time until it is now nearly completed; the bottom in many places was found to consist of an aggregation of small bowlders, cobble-stones, gravel, &c., strongly cemented together, which rendered the dredging exceedingly difficult.

In 1871, an appropriation of \$25,000 was made; in 1872, one of \$10,000; and in 1873, one of \$6,000.

The work of dredging, as laid out by the board of engineers, is nearly completed. The hard bottom of the Oswegatchie has been scraped, the channel parallel to the line of docks nearly completed, and that over the bar widened and deepened. It is not deemed advisable to commence the construction of the piers until the result of one more season is learned, in order to show whether they are necessary.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1874.

The opening of the fiscal year found operations in progress, dredging the channel in the St. Lawrence River parallel to the line of docks, under contract with Cornelius Daly, of Ogdensburgh, N. Y.

Six thousand one hundred and thirty cubic yards of mud and clay were removed from this channel, when operations were suspended upon it on account of lack of funds; the dredge was transferred to the channel over the bar, northeast of the light-house, and that channel was widened and deepened by removing 3,000 cubic yards of mud, clay, &c. Operations were suspended in August, 1873, the funds appropriated having been exhausted.

The condition of the harbor at present is as follows:

The channel over the bar, northeast of the light-house, is 300 feet wide, and presents a depth of from 11 to 17 feet at low water.

The Oswegatchie River has been dredged to the rock-bottom from just below the bridge to its mouth, and presents a channel 50 feet wide and 12 feet deep near the middle of the stream, sloping up to between 9 and 11 feet near the docks. The channel parallel to the line of docks, connecting the mouth of the Oswegatchie with the deep waters of the St. Lawrence, has been dredged to a depth of 12 feet at low water, and a width of 150 feet, for a distance of 4,300 feet; a small portion east of the ferry-dock is only 125 feet wide, but is to be dredged to the same width as the rest. The channel, when completed, will be 4,800 feet long, the lower 500 feet being yet incomplete, but presenting a depth of from 10 to 11 feet at present. During this season it is proposed to complete the channel in the St. Lawrence River, and to widen that over the bar, near the light-house.

It is recommended also that a channel 150 feet wide, similar to the one now almost completed in the St. Lawrence, shall be dredged from a point opposite the north end of the docks of the Northern Transportation Company up to the elevator, as a very large portion of the commercial interests of the place is centered at this locality. This would require the removal of about 15,000 cubic yards of mud, sand, &c., and would probably cost, including expenses of every character, about \$5,000. It is questioned whether this recommendation is in opposition to the report of the board of engineers of May, 1868, as they stated that it was the dredging at the wharves that should be done by the owners, while my proposition is to carry on the channel now being dredged to the elevator, keeping, as at present, 25 feet from the wharves.

The estimated cost of the present project for the improvement of this harbor was \$175,000, of which amount \$100,000 was to be devoted to dredging at various localities. Up to the close of the fiscal year ending June 30, 1874, the sum of \$102,000 has been appropriated, of which amount \$96,000 has been expended, in addition to the \$6,000 now available. About \$5,000 more will be required, should it be decided to dredge the channel near the docks of the Northern Transportation Company; \$70,000 will be required should circumstances render piers necessary, as indicated by the board of engineers in 1868.

Ogdensburg is a port of entry, in the collection-district of the Oswegatchie. There is a fixed white light of the fourth order near the entrance to the harbor.

Fort Ontario and Montgomery are each one hundred and twenty-five miles distant—the one to the southwest, the other to the east.

The amount of revenue collected during the fiscal year was \$224,364.35. The value of the imports was \$2,027,483. The value of the exports was \$602,522. The number of vessels entering was 1,069, with an aggregate tonnage of 264,726 tons. The number of vessels clearing was 1,060, with an aggregate tonnage of 259,412 tons.

There are three steam-ferries between this port and Canada, two of which make trips every half hour during the season of navigation.

An abstract of contracts in force, and a financial statement, are transmitted.

Financial statement.

Balance in Treasury of the United States July 1, 1873.....	\$3,092 72
Amount in hands of officer and subject to his check	2,644 97
Amount appropriated by act approved June 23, 1874	6,000 00
Amount expended during the fiscal year ending June 30, 1874	5,737 69
Amount available July 1, 1874	6,000 00
Amount required for the fiscal year ending June 30, 1876.....	5,000 00

Abstract of contracts for improving harbor at Ogdensburgh, N. Y., in force during the fiscal year ending June 30, 1874, by Maj. John M. Wilson, Corps of Engineers, United States Army.

Name of contractor and his residence.	Date of contract.	Subject of contract.	Dredging.		Remarks.
			Over the bar, near light-house, per cubic yard in scows.	Certain section of channel of Saint Lawrence River, per cubic yard in position.	
Cornelius Daly, Ogdensburgh, N. Y.	May 10, 1873.	Dredging	\$0 37	\$0 39	Contract closed August 1, 1873.

F 10.**WADDINGTON HARBOR, NEW YORK.**

A survey and examination of the harbor were made in August, 1872, and in March, 1873, an appropriation of \$10,000 was made for its improvement.

It was proposed to improve the harbor by opening a channel 200 feet wide and 11 feet deep through the bar at the head of Little River, the upper entrance to the harbor, and to facilitate the approach to the docks below the dam by removing materials from that locality.

It was determined to devote the appropriation of March, 1873, to the channel through the bar; and, after advertising, the work was awarded to Mr. H. J. Mowry, of Syracuse, N. Y., at the rate of \$1.24 per cubic yard, measured in position. Operations were commenced on July 30, 1873, and continued until October 25, 1873, when they were suspended, the contract being completed.

During this period the dredge worked 647 hours, and as the dredging was sometimes quite difficult, considerable breakage occurred, and it was idle for repairs from time to time.

The channel dredged was 200 feet wide, 400 feet long, and the depth obtained was from 11 to 12 feet at low water. The materials dug consisted of marl, stiff clay, mud, hard-pan, bowlders, and logs; the clay and hard-pan were calcareous.

The amount of material removed, measured in position, was 7,935 cubic yards; the amount measured in scows was 8,728 cubic yards, showing a gain of about 10 per cent. over the amount in position.

During the present season it is proposed to widen and straighten the

channel over the bar at the head of Little River, and to deepen the channel below the dam, to facilitate the approach to the docks.

At present there is an excellent channel, from 200 to 400 feet wide, from the head of Little River to the bridge; below the dam, a channel from 400 to 500 feet wide, and from 12 to 15 feet deep, is found, until within 200 feet of the ferry-dock. It is proposed to carry this channel up to the dock.

The original estimated cost of the improvement of this harbor was \$17,000. Up to the close of the fiscal year ending June 30, 1874, \$20,000 has been appropriated, of which amount \$9,987.69 has been expended. No further appropriation will be required.

Waddington is a port of entry, in the collection-district of the Oswegatchie. The nearest light-house is at Ogdensburgh; and Fort Montgomery, one hundred miles distant, is the nearest work of defense.

The amount of revenue collected during the fiscal year was \$18,022.92.

The value of the imports was \$124,050.00. The value of the exports was \$1,164.00.

Twenty-seven vessels, with an aggregate tonnage of 1,187 tons, entered, and 31 vessels, with an aggregate tonnage of 1,278 tons, cleared.

An abstract of contracts in force is transmitted, also a financial statement.

Financial statement.

Balance in Treasury of United States July 1, 1873	\$6,700 00
Amount in hands of officer and subject to his check	3,270 25
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874	9,957 94
Amount available July 1, 1874	10,012 31
Amount required for the fiscal year ending June 30, 1876	Nothing.

Abstract of contracts for improving harbor at Waddington, N. Y., in force during the fiscal year ending June 30, 1874, by Maj. John M. Wilson, Corps of Engineers, United States Army.

Name and residence of contractor.	Date of contract.	Subject of contract.	Dredging from the bar at the upper end of Little River, the entrance to harbor of Waddington.	Remarks.
Henry J. Mowry, Syracuse, N. Y.	May 12, 1873	Dredging.	\$1.24 per cubic yard, measured in position; 7,000 cubic yards, more or less.	Contract closed October 27, 1873.

APPENDIX G.

ANNUAL REPORT OF LIEUTENANT-COLONEL JOHN NEWTON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1874.

UNITED STATES ENGINEER OFFICE,
New York, August 20, 1874.

GENERAL: I have the honor to transmit herewith the annual reports upon the works under my charge for the fiscal year ending June 30, 1874.

Very respectfully, your obedient servant,

JOHN NEWTON,
Lieut. Col. of Engineers, Bvt. Maj. Gen.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

G 1.

IMPROVING HARBOR AT PLATTSBURGH, NEW YORK.

During the year the superstructure of the extension of 100 feet to the breakwater, under contract with James D. Leary, was completed, and the crib-work of the extension of 56 feet, under contract with Luther Whitney, was completed and filled with stone. The superstructure will be completed between July 1 and December 31, 1874.

With the amount appropriated by act of Congress approved June 23, 1874, it is proposed to make certain repairs to the south end of the breakwater, by replacement of logs which have been broken out, and to filling places where the stone has settled; these repairs are all on the old breakwater.

No further appropriation is asked.

Name of collection-district, Champlain.
Plattsburgh is port of entry.

Financial statement.

Balance in Treasury of United States July 1, 1873	\$10,000 00
Amount in hands of officer and subject to his check	5,095 67
Amount appropriated by act approved June 23, 1874	5,000 00
Amount expended during the fiscal year ending June 30, 1874	8,242 88
Amount available July 1, 1874	10,116 79

G 2.

IMPROVING HARBOR AT BURLINGTON, VERMONT.

During the year the superstructure of the extension of 180 feet of breakwater, under contract with Luther Whitney, was completed. In June, 1873, contract was made with Chas. J. De Graw for an extension of 220 feet of breakwater, but this contract was annulled on 25th August, 1873, for the reason that the contractor had failed up to that date to commence operations, having, instead, devoted his time to making efforts to have the contract extended, alleging his inability to procure the necessary timber for the cribs in order to complete them by the specified time, although it was definitely understood at the time of signing the contract that no extension would be allowed; the contract was, therefore, annulled, and, by approval of the Chief of Engineers, the work was awarded to Luther Whitney, the next lowest bidder; and under contract with him, two cribs, each 110 feet in length, were completed within the specified time, viz, December 31, 1873.

The superstructure for this extension will be completed between July 1 and December 31, 1874.

Under appropriation of June 23, 1874, it is proposed to extend the breakwater from the north end, in a direction nearly northwest.

HISTORY OF THE WORK.

A special board of engineers in 1867 recommended an extension of this breakwater in a northerly direction for a length of 1,500 feet; when I took charge in May, 1870, there remained of this length to be constructed 840 feet. Contracts were entered into during that year for a

further extension of 171 feet, which being completed, there remained 669 feet of the length prescribed by the board to be constructed. But by permission of the Chief of Engineers, the extension to the northward has been suspended for several years, to devote the sums appropriated by Congress to a southerly elongation, which, by the growth of the water-front in that direction, had become necessary. A length of 617 feet has, in pursuance of this object, been added, and is considered sufficient for the present, and until a further growth of wharves and business to the southward.

It is proposed to devote the appropriation approved June 23, 1874, to an extension in a northwest direction to protect the growth of wharves to the northward, and Assistant D. White writes that the total length of such extension will ultimately be 2,000 feet, at a cost of \$1.70 per linear foot; amounting in the aggregate to \$340,000.

An appropriation of \$40,000 is asked.

Name of collection-district, Vermont. Burlington is a port of entry.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$40,145 99
Amount in hands of officer and subject to his check.....	11,440 51
Amount appropriated by act approved June 23, 1874.....	25,000 00
Amount expended during the fiscal year ending June 30, 1874.....	39,742 61
Amount available July 1, 1874.....	27,460 89
Amount required for the fiscal year ending June 30, 1876.....	40,000 00

G 3.

IMPROVING HARBOR AT SWANTON, VERMONT.

Under contract with Luther Whitney, one crib, 110 feet long, for breakwater, was completed and filled with stone during the month of September, 1873; the superstructure will be constructed between July 1 and December 31, 1874.

Under appropriation of June 23, 1874, it is proposed to continue the breakwater on the line already adopted.

For completing the improvement of this harbor the sum of \$249,160 will be required.

ORIGINAL ESTIMATE.

1,900 linear feet, breakwater.....	\$272,160 00
Amount appropriated.....	23,000 00
Amount expended.....	8,241 65

Swanton Harbor is in the collection-district of Vermont.

Fort Montgomery is the nearest fort. The nearest light-house is on Windmill Point.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$15,000 00
Amount appropriated by act approved June 23, 1874.....	8,000 00
Amount expended during the fiscal year ending June 30, 1874.....	8,241 65
Amount available July 1, 1874.....	10,193 35
Amount required for the fiscal year ending June 30, 1876, (to complete the improvement).....	249,160 00

G 4.

IMPROVING OTTER CREEK, VERMONT.

In consequence of the failure of E. R. Seward to fulfill his contract for dredging this creek, the work was re-advertised for proposals, to be opened on August 13, 1873, and but one proposal was received; this, being for 60 cents per cubic yard, was considered too high, and inquiries were made by Mr. White, my assistant on Lake Champlain, to see if a dredge could not be found in that vicinity to do the work at a reasonable rate; after some delay, an offer was made by Mr. J. D. Hancock for 40 cents per cubic yard, which was accepted, and contract entered into with him to do the work.

Operations were commenced in September, 1873, and were restricted to the improvement of those points of the creek which were found to be the most embarrassing to its navigation, viz: at Brick-Yard, a channel of 70 feet in width and 8 feet deep, at mean low water, has been dredged through the shoal; and at "Smith's Bend" and "Bull Brook" the channel has also been widened and deepened to about the same extent.

At the steamboat-landing and vicinity, the creek, to nearly its whole width, has been cleared of silt, sunken timber, and bowlders.

The basin from the docks on the east bank, to nearly two-thirds of its width, and extending from the steamboat-landing to the upper coal-dock, has been dredged to the required depth.

The amount of materials removed from the different points dredged is as follows:

	Cubic yards.
At Brick-Yard.....	3,200
At Smith's Bend.....	6,000
At Bull Brook.....	4,762
At Vergennes Basin.....	5,750
Total	19,712

Consisting of clay, sand, gravel, silt, stone, and saw-mill *débris*.

The improvement thus made enables vessels to reach the wharves at any point on the east side of the basin.

And for the improvement of the navigation of the west side of the basin, in order to facilitate the shipment of freight by the manufacturing establishments located on the west shore, near the foot of the falls, and for completing the improvement of the channel, the sum of \$48,146 will be required.

ORIGINAL ESTIMATE.

Dredging, diking, and fascine work.....	\$57,646 00
Removing trees.....	500 00
	58,146 00
Amount appropriated.....	\$10,000 00
Amount expended.....	9,772 73

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$7,500 00
Amount in hands of officer and subject to his check.....	2,074 13
Amount expended during the fiscal year ending June 30, 1874.....	9,346 86
Amount available July 1, 1874.....	227 27
Amount required for the fiscal year ending June 30, 1876, (to complete the improvement).....	48,000 00

APPENDIX H.

ANNUAL REPORT OF MAJOR F. U. FARQUHAR, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1874.

[Letter of transmittal under Appendix A.]

H 1.

PRESERVATION OF THE FALLS OF SAINT ANTHONY, AND NAVIGATION OF THE MISSISSIPPI RIVER.

Owing to the small amount of funds available, the work has been confined to the repair of damages caused by the freshet in the spring of 1873, and securing the upper portion of the tunnel from further incursions of water from the river.

During the first half of July, 1873, the tunnel being filled with water and the river at a high stage, all work was suspended except that of framing timber for the bulk-head under the shaft. On the 15th of July the water was drawn off from the tunnel, and the work of clearing out *débris* from the second break to the shaft commenced. A passage was cut through the masonry bulk-head where it had been undermined, and a large amount of fallen rock and sand removed.

On the 29th of July work was commenced on the bulk-head under the shaft. This consisted of a crib-work of timbers 12 inches square, laid 2 feet apart in each direction, and framed together, having a base of 32 feet with a batter of one-third on each face.

The interstices between the timbers were filled with well-rammed concrete, composed of one part Louisville cement, two parts sand, and five parts broken limestone. A sewer of iron pipe 36 inches in diameter was laid through the bulk-head along the floor of the tunnel, and continued to about the middle of the second break, a distance of 252 feet. The flow of water through this sewer is controlled by a gate at the lower side of the bulk-head, operated through the shaft. The excavation formed by the washing out of the sand-rock at the west end of the masonry bulk-head was cleared out, floored with concrete, and a lining of timber and masonry built. Stone walls were built in the upper part of the tunnel wherever required to support the limestone ledge; the above work being completed about the middle of September. The tunnel from the new bulk-head to the upper end of the sewer-pipe was filled with well-rammed gravel, brought by portable railroad from the hill on the east bank of the river. A cross-wall of concrete 4 feet in depth was put in below the floor at the back of the masonry bulk-head. At the upper end of the floor a trench was dug to the undisturbed sand-rock and filled with gravel. The floor was found to be undermined near the center of the tunnel to a depth of about 6 feet.

The portion of the tunnel filled has a uniform depth of 16 feet, and varies in width from 35 to 120 feet. The total amount of gravel put in was about 11,000 cubic yards, at a cost of about 50 cents per yard. The filling was finished November 28, and the appropriation being nearly exhausted, work was suspended for the winter.

It was thought advisable that the space inclosed by the coffer-dams be overflowed during the winter, and with this intention the portion of

the tunnel above the gravel-plug was allowed to fill with water; but as this largely increased the flow from the spring at the bifurcation of the tunnel, the water was again drawn off. The citizens of Minneapolis having raised funds for the purpose, work was resumed on the 14th of February, 1874.

The first work undertaken was the clearing out and filling with gravel of the channel on the east side of Nicollet Island, formed by the break of July 3, 1871. A trench was dug along the east side down to the hard stratum of sand-rock, drains laid to convey several small springs to the iron sewer-pipe, and the entire channel filled with gravel, well rammed. Several small channels in the soft stratum of sand-rock were found, through which water passed to the spring at the bifurcation of the tunnel. After the drains were laid the flow from the spring diminished from 230 to 80 gallons per minute, and has continued since to flow at the latter rate. The fallen rock and *débris* in the upper part of the second break were removed, and this, together with the lower part of the channel from the first break, filled with gravel. The lower part of the channel from the break of May 17, 1873, 325 feet in length, has been cleared out, drained, and filled. A timber bulk-head has been built in the west branch below the bifurcation, and a gravel plug 50 feet in length has been put in below the end of the lining in the main tunnel.

Before the spring freshet the deep holes in the bed of the river at head of the ledge, outside the bank, were filled to a level with the top of the ledge with stone and gravel, protected by heavy riprap. The amount raised by the citizens for the above work was \$17,157.50.

Since June 13, 1874, when the funds furnished by the citizens were exhausted, work has been continued with the balance of the appropriation of 1873, which will be sufficient to complete the filling of the second break.

April 15, 1874, a board of engineers assembled in Minneapolis for the purpose of considering the plan for the preservation of the Falls of Saint Anthony, and forwarded a report which I would respectfully request might be printed with this report in annual report to Congress.

If the \$200,000 asked for this improvement had been appropriated in 1872, so that the plan recommended by the board of engineers of that year could have been carried out, I think there is no doubt that the work would now be finished; but, as will be seen above, the amount appropriated by act approved March 3, 1873, was entirely expended in meeting the continually-occurring emergencies.

Of the amount appropriated by act approved June 23, 1874, (\$150,000,) \$125,000 will be expended in constructing the wall or dike recommended by the board of engineers assembled in April, 1874, and the remaining \$25,000 will be expended in removing obstructions in the Mississippi River between the Falls of Saint Anthony and Sauk Rapids.

I would recommend that an appropriation of \$200,000 be asked for, for continuing the work at the Falls of Saint Anthony in accordance with the recommendation of the above-named board of engineers.

The further improvement of the Upper Mississippi River will be made the subject of a future report after a careful survey of the river has been made.

Financial statement.

Balance in Treasury of United States July 1, 1873	\$20,000 00
Amount in hands of officer and subject to his check, (including \$5,244.62 due on material not yet paid for)	21,880 78
Amount appropriated by act approved June 23, 1874	150,000 00
Amount expended during the fiscal year ending June 30, 1874	35,147 63
Amount available July 1, 1874	151,488 53
Amount required for the fiscal year ending June 30, 1876	200,000 00

H 2.

PRESERVATION OF THE FALLS OF SAINT ANTHONY, MINNESOTA.

Report of Board of Engineers.

{Special Orders.]

No. 32.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., March 26, 1874.

A board of officers of the Corps of Engineers, to consist of Col. J. N. Macomb, Lieut. Col. J. D. Kurtz, Maj. G. Weitzel, Maj. O. M. Poe, Maj. F. U. Farquhar, will assemble at Minneapolis, Minn., on the 14th day of April, 1874, or as soon thereafter as practicable, to consider and report upon the subject of the preservation of the Falls of Saint Anthony.

By command of Brig. Gen. HUMPHREYS.

THOS. LINCOLN CASEY,
Major of Engineers.

The board met in Minneapolis, April 15, 1874, in pursuance of the above order, present all the members.

Major Farquhar laid before the board all the information in his possession.

The board having made a care personal examination of the locality and works, and having discussed the questions of the proper plans for the preservation of the Falls of Saint Anthony, submit the following

REPORT.

I.—HISTORY OF THE FALLS OF SAINT ANTHONY FROM THE COMMENCEMENT OF THE EXCAVATING OF THE TUNNEL TO THE PRESENT TIME.

On the 7th of September, 1868, a company known as the Tunnel Company commenced the excavation of a tunnel at a point near foot of Hennepin Island, (marked A on accompanying tracing,) and continued this up under the island towards the foot of Nicollet Island. This was excavated for the purpose of forming a tail-race under the sites of manufactories to be built. The water to furnish the power for these manufactories was to be introduced from the level of the mill-ponds on either side of Nicollet Island.

On the 4th of October, 1869, this excavation had reached a point under the foot of Nicollet Island, when the workmen were driven away and the tunnel invaded by the waters of the Mississippi River coming in from a point marked B at the head of the limestone ledge. The original cross-section of the tunnel was 6 by 6 feet, but in a very short time the rushing waters excavated a much larger cross-section, (16½ feet high by from 10 to 90 feet wide.) In a few days so much of the sand-rock between Nicollet and Hennepin islands was washed out that a large portion of the superincumbent lime-rock fell into the tunnel, (opening marked F.) After great effort on the part of the citizens a rude coffer-dam was constructed inclosing a space extending from above the point B on the west side of Nicollet Island down stream to the head of Hennepin Island, and another connecting the east sides of the foot of Nicollet and head of Hennepin Islands.

This almost entirely checked the flow of water through the tunnel. The tunnel was then plugged at the lower end of the break between the

two islands and the opening covered over, thus forming a new floor to the bed of the river between the two islands.

The river and harbor appropriation bill approved July 11, 1870, made the first appropriation for the preservation of the Falls of Saint Anthony. The amount appropriated was \$50,000. Under this appropriation Col. J. N. Macomb took charge of the work.

The following report of Franklin Cook, engineer in local charge, gives the history of the work during the fiscal year ending June 30, 1871:

[See Annual Report of the Chief of Engineers for 1871, pp. 294-7.]

During the fall of 1870 the citizens of Minneapolis commenced the building of the great wooden apron to protect the foot of the falls, and continued this work during the following winter.

The river and harbor appropriation bill approved March 3, 1871, appropriated \$50,000.

On the 3d of July, 1871, a break into the tunnel from the east side of Nicollet Island occurred. The following report of Mr. Cook, and letter of Colonel Macomb transmitting the same to the Chief of Engineers, give a full account of this new trouble. This break is marked C on accompanying tracing.

[See Annual Report of the Chief of Engineers for 1871, pp. 297-8.]

The new channel, marked D, from the tunnel to near the foot of the falls on west side of Hennepin Island, described in the above report, caused great alarm, and the citizens at once set to work to raise the necessary funds to line the tunnel. By the last of August, 1871, they had raised \$100,000 for the lining of the tunnel and the building of the apron to protect the foot of the falls.

The work done by the United States and the citizens of Minneapolis during fiscal year ending June 30, 1872, is set forth in the following reports, taken from the annual report of the Chief of Engineers for 1872:

[See Annual Report of the Chief of Engineers for 1872, pp. 296-306.]

The amount appropriated for this work in the river and harbor bill approved June 10, 1872, was \$50,000.

The history of the work during the fiscal year ending June 30, 1873, is given in the Annual Report of the Chief of Engineers for 1873. Maj. F. U. Farquhar relieved Col. J. N. Macomb of the charge of this work April, 1873.

[See Annual Report of the Chief of Engineers for 1873, pp. 408-11.]

The river and harbor bill approved March 3, 1873, appropriated \$50,000 for this work.

The work accomplished during the first half of the present fiscal year is described in the following reports transmitted to the Chief of Engineers December 10, 1873:

UNITED STATES ENGINEER OFFICE,
Saint Paul, December 10, 1873.

GENERAL: I have the honor to make the following report of operations, during the past season, of the Falls of Saint Anthony, and also a report of the present condition of the work at that place. As soon as the high water of the Mississippi River had sufficiently subsided work was commenced to repair the damages caused by breaches through the cofferdams and through the soft sand-rock underlying the limestone between the head of the ledge and the mouth of the tunnel between Hennepin

and Nicollet Islands. The damaged portions of the lining of the tunnel were rebuilt and a new bulk-head was constructed, so that the gate in it could be worked from the shaft. A 36-inch cast-iron drain-pipe was laid from the bulk-head to the upper end of the opening between the above-mentioned islands. The tunnel for 250 feet above the bulk-head was carefully filled with well-rammed gravel. In filling the tunnel great care was taken to prevent any water from passing along under the flooring. At two places cross-trenches were excavated to 4 feet below the floor, and carefully filled with concrete.

It was found that during the high water an entirely new channel from the head of the ledge under the limestone to the tunnel had been made. It is a significant fact that the bottom of this new channel was at the bottom of the soft stratum, and the top in many places did not reach to the lime-rock. This "soft stratum" is $16\frac{1}{2}$ feet below the lime-rock, and its bottom was the lower limit of the tunnel-floor before it was lined, and it was through it that the water made its appearance in 1869, while the original tunnel was being excavated. The head of the new channel was closed by extending the earth-embankment at the head of the ledge.

The work above described was finished November 29. December 2 the gate through the bulk-head was closed, and the water filled up the pit between the islands. The accompanying report of Assistant J. L. Gillespie gives the result of this raising of the head of water. It will be seen that no water passed through the bulk-head, the only increase of water at the back of the bulk-head being from a seam in the lime-rock, the lower stratum of the lime-rock having fallen, leaving a ragged projection. The water coming through this seam was perfectly clear, which showed that it had not come through the gravel-plug. But while I feel not the least anxiety about the bulk-head, the effect of the increased head of water on a spring 370 feet below the bulk-head causes me much uneasiness. This spring was met by the workmen in 1869 in excavating the tunnel, and the water from it used for drinking purposes by the men. After the tunnel was invaded by the Mississippi River, and the work of lining the tunnel commenced, this spring was introduced through the lining by a 4-inch pipe.

When I took charge of the work the tunnel was filled with water by reason of the breaks through the coffer-dams. When the water was drawn off the mouth of this spring was covered with several feet of sand and water, and its existence was not known to me until a few days ago. The excavators of the tunnel did not think that there was any connection between it and the river above the head of the ledge, but with the results before us it cannot be doubted that it has, and that this connection is outside of the line of the tunnel. I am more than ever convinced that the proper place to build the proposed water-tight dam, to cut all the water flowing through the sand-rock, is as near the crest of the natural falls as possible. There are two prominent reasons for this: 1st, that it will cut off all the water percolating through the sand-rock; and 2d, that in the process of its construction we will run no risks not already existing. This work should be commenced at once, but, unfortunately, there is no money. There is now on hand available for this work only \$6,000. If it could be begun now more than half of it could be finished before the occurring of high water in the Mississippi River next spring. This work can be prosecuted as well during the winter as at any other time, and, as labor is cheaper, more economically. I would most earnestly recommend that Congress be asked to make an immediate appropriation, as asked for in my annual report.

The dangers to the falls by reason of causes acting above the limestone can easily be detected and averted, but the danger from the percolating of water through the soft sand-rock can only be known after the damage is done, and this danger should be removed as soon as possible.

I transmit herewith, besides Assistant Engineer Gillespie's report, two tracings; one showing the tunnel in plan on a large scale, and the other showing the proposed dam in reference to the adjoining topography.

I have the honor to be, very respectfully, your obedient servant,
F. U. FARQUHAR,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Report of Mr. J. L. Gillespie, Assistant Engineer.

UNITED STATES ENGINEER OFFICE,
Minneapolis, Minn., December 10, 1873.

SIR: I have the honor to submit the following report of observation on the spring in the Saint Anthony tunnel, made in accordance with your instructions, while raising the head of water in the pit at the foot of Nicollet Island.

This spring is situated at the bifurcation of the tunnel, being brought through the lining on the east side by a pipe, 4 inches in diameter, just above the floor.

Its position is shown by the accompanying tracing. This part of the tunnel is now filled to the depth of 7 feet with fine sand and gravel, which was carried in by the freshet of last spring. In the usual condition of the spring there is a moderate and even flow of clear water, with slight ebullition.

The water was first admitted to the pit at noon of Tuesday, December 2.

The water rose slowly until Thursday, at four p. m., when it was about 2 feet below the top of the ledge.

At this time the water of the spring was boiling up violently about 3 inches above the general surface of the water in the tunnel. The gate in the new bulk-head was then raised, and the water in the pit drawn off.

On the 8th instant the water was again admitted, and simultaneous observations made on a water-gauge in the pit at the back of the new bulk-head and at the spring.

The result of these observations is shown in the annexed table.

The water at the back of the bulk-head comes through the horizontal seam between the two lower strata of the limestone, and has been at all times perfectly clear, showing that no washing of the sand-rock or gravel has taken place at that point.

The lower strata of the limestone over the central portion of the tunnel from the pit to a point about 30 feet below the new bulk-head has been removed. Below this point it is intact.

After drawing off the water from the pit the spring returned at once to its usual condition.

Very respectfully, your obedient servant,

J. L. GILLESPIE,
Assistant Engineer.

Maj. F. U. FARQUHAR,
Corps of Engineers, U. S. A.

DECEMBER 8, 1873.

Observations made while raising water in pit between Nicollet and Hennepin Island.

Time.	Reading of gauge.	At back of bulk-head.	At spring.
<i>Hr. Min.</i>			
1 10	0.7		Spring as usual, bubbling slightly.
20	0.9		Slight increase.
30	1.1		As at first.
40	1.3	Water trickling through seam in ledge and on back of bulk-head 6' from lining near bottom, west side, 3 1/4' from lining near bottom, east side. Amount of water, d.	Boiling almost steadily 3" high.
50	1.5		1.58 boiling stopped entirely.
2 00	1.8		Some sand running out.
10	2.0		
30	2.4	Water on 5th course from top 14', west side....	Boiling slightly, as at first.
40	2.6	Water on 5th course from top 14' to gate, east side	Increasing slightly.
50	2.9	Amount of water 1 1/4 west side	As at first.
50	3.1	Amount of water 2 east side	
3 00	3.4	Water from seam west, 2	Increasing slightly.
10	3.6	Water slowly increasing	
20	3.8	do	Boiling increased; not as much as at 1.40.
30	4.0	do	
40	4.2	do	} About as at 1.40, boiling up about 3", 8 or 10 times a minute.
50	4.4	do	
4 00	4.7	Amount of water, 3	No change.
10	4.9	No further change	Do.
20	5.1	do	Do.
30	5.3	do	Do.
40	5.5	do	Do.
50	5.5	do	Do.
5 00	5.5	do	Do.

DECEMBER 9, 1873—8 A. M.

At back of bulk-head.—Amount of water about the same as last night.*At spring.*—No boiling; considerable sand has come in during the night, and is still running. Gauge raised the gate.*Gauge-reading.*—Zero of gauge, 12 feet below the top of ledge. Reading at bottom of ledge, 2.7.

The citizens of Minneapolis, fearing that some disaster might happen during the expected spring freshet of this year, subscribed the sum of \$13,000, to be expended in attempting to cut off the connections between the spring at the bifurcation of the tunnel and the east branch at the upper end of the tunnel. A trench on the east side of this branch has been excavated to the soft layer, and a 12-inch sewer laid from the upper end of the branch to the drain-pipe of the main tunnel. Although no distinct channel was found leading to the spring, yet the water lead into this drain reduced the flow at the spring from 230 gallons per minute to 80 gallons per minute. The east branch is being filled with well-rammed gravel. Some pieces of timber were put in the apron to replace portions of the covering carried away by the ice passing over the falls. Total amount appropriated by the United States, \$200,000. Amount expended by citizens of Minneapolis, \$232,000.

II.—PRESENT CONDITION OF FALLS OF SAINT ANTHONY.

From all the experience gained during the past year there can be no doubt that there is a connection between the river above the limestone ledge through the soft stratum of sand-rock (about 14 feet below the lime-rock) and the spring at the bifurcation of the tunnel below the gravel-plug. Whether this is a uniform channel or a series of cavities connected together is not known, but from experiments made by raising the head of the out-flow of the spring it would seem that for a difference of 2 feet 5 inches in height the volume of the cavities amounts to 8,000

cubic feet. These experiments were not carried to the extent of raising the head of the out-flow to the under side of the limestone for fear of the water forcing a passage around the lower end of the lining, which only extended some 25 feet below the spring. It is hoped that the amount raised by the citizens, together with the small sum unexpended of the last appropriation, may suffice to finish the plugging of the east branch, the extending of the lining below the spring some 40 feet, and the putting in of two timber bulk-heads in the lower branches of the tunnel below the spring. A portion of the toe of the apron at the west side was broken down by the ice resting upon it, which cannot be repaired until low water. The openings through the upper portion of the limestone ledge (marked E) will also be plugged with well-rammed gravel.

III.—PLANS AND RECOMMENDATIONS OF THE BOARD FOR THE PRESERVATION OF THE FALLS.

In considering the plans for the preservation of the Falls of Saint Anthony it may be well to recapitulate the existing dangers:

1st. There is the danger of the destruction of the limestone covering at the falls by reason of the upper layers being disintegrated and separated by the action of frost, and carried away by the erosive action of heavy bodies of ice and logs passing over the falls. There is less immediate danger from this cause than from the following:

2d. The constant wearing away of the sandstone at the foot of the falls by the falling water, and the consequent falling down of the limestone, which process was very rapid previous to the building of the existing apron.

3d. The danger of the water passing from the head of the ledge through the sandstone, under the limestone covering, to the foot of the falls. The danger from this cause is at present the most threatening of all. In general terms, the first danger would be obviated by having a depth of at least 4 feet of water over all parts of the limestone; the second, by keeping in good repair and extending the existing apron; and the third, by a dike extending from a dry stratum of the sand-rock, below the *soft* strata up to the limestone ledge, and the wall recommended by the board of 1872.

The board, therefore, presents the following plans and estimates for the execution of the works immediately necessary:

1st. Two dams should be constructed along the lines G and H, of timber cribs, well bolted to the rock and filled with stone, to have an upper slope of $\frac{1}{2}$ and a lower slope of $\frac{1}{2}$, both slopes to be covered with 12-inch squared timber. The foot of the lower dam to be connected with the apron, and the upper dam to have a toe 20 feet in width, and all salient angles to be covered with boiler plates. The lower dam should be $4\frac{1}{2}$ feet high, and the upper 4 feet high. A tracing showing cross-sections of these dams is herewith appended. It is estimated that these dams will cost \$24,420.

2d. The apron should be put in thorough repair, and extended down stream on the west side of Hennepin Island. The amount required for this work is estimated at \$65,000.

3d. From the description of the present condition of affairs and the history of what has taken place at the locality since the board of engineers met at Minneapolis in August, 1872, it is apparent that the dangers threatening the integrity of the Falls of Saint Anthony have considerably increased, and are of such a nature as to convince the pres-

ent board that the opinions then expressed were correct. The present board is satisfied that if the funds had been provided to carry into effect the recommendations then made, the remedial measures would have proven as complete as the nature of the case admitted, or as the board of 1872 expected.

But the changed conditions, while they indicate the propriety of the former recommendations, render advisable some modification of the measures to be at once adopted, leaving to the future the carrying into effect of the principal features of the original plan.

The development of the connection between "break No. 3" and the spring at the bifurcation of the tunnel and the "fourth break" into the tunnel, indicate disturbances in the soft or boulder stratum of unknown extent and location.

The wall at the head of the limestone ledge, proposed by the board of 1872, would effectually cut off the percolations through the soft stratum beneath the limestone and prevent the dangers arising from such percolation, but its construction now would be attended with greater difficulty as well as greater risk, and the cost would be much greater than was formerly estimated.

The board is now reluctantly constrained to recommend that measures more readily executed and involving less expenditure be undertaken and completed as soon as practicable, with the view of preventing additional injuries resulting to the falls, which may hasten their final destruction.

These measures are the introduction of a dike of concrete to extend across the river at a position lower down the channel, along a line a short distance above the apron on the Minneapolis side, upon the *trace* indicated on the drawing which accompanies this report. This dike should be constructed in a tunnel to be excavated on the proposed line, whose bottom should be in that homogeneous stratum which is some 38 feet below the limestone, extending up to the limestone, and at least 4 feet in width.

This plan of a dike is only proposed because of the change of circumstances since the report of the board of engineers of 1872, rendering a more speedy relief necessary, and because it now seems to present less difficulties in its construction, and will serve to do away with a very great danger, existing by reason of the rapid disintegration of the sand-rock near the head of the ledge.

The board is of the opinion that the plan of the board of 1872 should ultimately be carried out, and the whole mass of the sandstone between the crest of the falls and the head of the ledge be preserved by inclosing it between the wall proposed by the board of 1872 and the dike now recommended to be constructed. The length of the dike would be about 2,000 feet, and is estimated to cost as follows:

For excavating	\$11, 852
For wall	118, 520
	130, 372
Wall recommended by board of 1872	200, 000
	330, 372

RECAPITULATION.

For dam on top of limestone	\$24, 420
For completion and repairs of apron	65, 000
For dike under limestone	130, 372
For wall at head of ledge	200, 000
Total cost	419, 792

Of the amount estimated the sum of \$219,792 should be made immediately available. Experience has clearly demonstrated the correctness of the recommendation of the board of 1872, that only a sum as large as this will enable any one to solve this problem.

The smaller sums which have been appropriated for this work, both by Congress and individuals, since that time have been exclusively expended in repairing damages which occurred in consequence of the utter inability of those in charge to carry out the thorough plan for want of funds. The board cannot conclude without expressing its regret, that notwithstanding the recommendations of the board of 1872, with reference to obstructions placed in the bed of the river at this locality, none of them have been removed, but on the contrary new ones erected.

It is strange that the interests dependent upon the preservation of the Falls of Saint Anthony should continue to employ means tending so strongly to its entire destruction, and the board must renew the condemnation expressed by the board of 1872 of this practice.

All of which is respectfully submitted.

J. N. MACOMB,
Colonel of Engineers, U. S. A.
J. D. KURTZ,
Lieut. Col. of Engineers.
G. WEITZEL,
Major of Engineers.
O. M. POE,
Major of Engineers.
F. U. FARQUHAR,
Major of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Correspondence relative to money contributed by the citizens of Minneapolis, Minnesota.

UNITED STATES ENGINEER OFFICE,
Saint Paul, Minn., May 9, 1874.

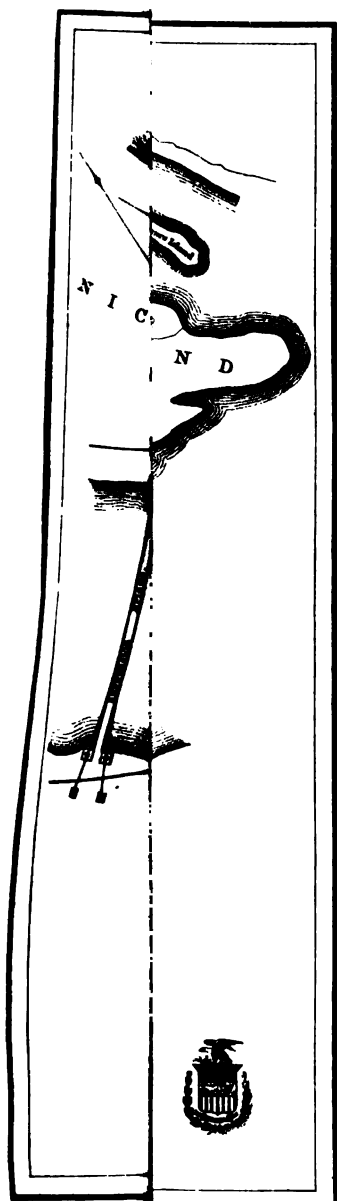
GENERAL: I have the honor to inclose a copy of a letter just received from H. T. Welles, esq., who was president of one of the committees of citizens of Minneapolis under whose supervision the money contributed by the citizens for the preservation of the Falls of Saint Anthony was expended.

By it will be seen that the amount reported by the board of engineers convened in Minneapolis during the last month, as contributed by the citizens and city of Minneapolis, was too small. The amount should be, as per inclosed letter \$333,000. The amount reported by the board was taken from the report made by the citizens of Minneapolis to the board of 1872, (see page 304 Annual Report of the Chief of Engineers for 1872.) I have no doubt Mr. Welles' figures are correct, and that the report of the board of engineers for 1874 should be amended.

Very respectfully, your obedient servant,

F. U. FARQUHAR,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.



STATION, PHOTO-LITHOGRAPH, WASHINGTON, D. C.

MINNEAPOLIS, MINN., May 8, 1874.

DEAR SIR: The enclosed letter explains itself.

The expenditures of the city of Minneapolis on the work for preservation of the falls has been—

In 1869.....	\$80,000	
In 1871.....	84,500	
		<u>\$164,500</u>

The city, by private contribution—

In 1867.....	35,000	
In 1869.....	22,000	
In 1870.....	50,000	
In 1871.....	22,000	
In 1872.....	22,500	
In 1874.....	17,000	
		<u>168,500</u>

Total.....		<u>333,000</u>
------------	--	----------------

Please make the correction as desired by Mr. Chute, if you can.

Yours,

H. T. WELLES.

Colonel FARQUHAR.

My statement is correct and agrees with one already before the committee of both houses, except as to the \$17,000, which I did not put in, not having been raised when I made my statement.

H 3.

CONSTRUCTION OF LOCK AND DAM ON MISSISSIPPI RIVER AT MEEKER'S ISLAND, MINNESOTA.

No funds were available for this work, as the parties holding the land grant for building this work did not make the release required by the act approved March 3, 1873, until the spring of the present year, and I have not been informed whether said release was acceptable to the United States.

A resurvey of the proposed site of the lock and dam was made to determine the location. Considerable work was done on the plans for the lock and dam—all that can be done until borings are made over the proposed site, which cannot be made until the appropriation is made available.

Enough is known, however—

That a masonry lock 300, feet long, 80 feet wide, and 17 feet lift, will cost about.....	\$630,261 46
And a timber dam.....	<u>291,860 00</u>

Making the total cost of improvement.....	922,121 46
---	------------

The cost is so large owing to the fact that the faces of the work should be of granite masonry, as I do not think the limestone of this country good enough for such an important structure, and that extra precautions will have to be taken to prevent the water, after the works are completed, from undermining them, as they must be founded on the soft sand-rock, which has been found so troublesome at the Falls of St. Anthony.

If this work is to be prosecuted economically, a sum of not less than \$300,000 should be appropriated for the fiscal year ending June 30, 1876.

The river traffic at present would hardly justify such an expenditure, although in the future it may become a necessity.

If it be determined by Congress to improve the navigation of the Mississippi River so that vessels can pass the Falls of St. Anthony, then the lock and dam near Meeker Island will become a necessity, but until such a thorough plan of improvement is adopted the expediency of expending so large a sum of money to extend navigation only fifteen miles may well be questioned.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$25,000
Amount available July 1, 1874	25,000
Amount required for the fiscal year ending June 30, 1876.....	300,000

H 4.

IMPROVING MINNESOTA RIVER, MINNESOTA.

Owing to the high stage of water in the early part of the season of 1873, work was not commenced until September, and it was continued until the middle of March, when the ice became dangerous for the men.

The work accomplished was the removal of rocky ledges crossing the stream between Minnesota Falls and the mouth of the Yellow Medicine, and bowlders, snags, and overhanging trees, in detail, as follows:

Rock in places.....	cubic yards..	119
Bowlders	do.....	408
Snags.....		519
Overhanging trees.....		777

The river was also cleared of snags and overhanging trees from the mouth of the Yellow Medicine to center of section 1, township 114, range 38; the work in this section amounting to 667 snags removed from the bed of the river, and 598 overhanging trees cut down and removed from the river-bank. Afterward work was commenced where contractor had left off the year before, (near Golden Gate, section 21, township 111, range 32,) and continued down stream to Judson, except some three miles of the river between center of section 25, township 109, range 29, and east line of section 29, township 109, range 28. In this section there were removed 1,523 snags, and 1,734 overhanging trees cut down.

With the \$10,000 appropriated by river and harbor bill, approved June 23, 1874, it is proposed to carry on the survey of the river, for the purpose of determining the exact location and cost of the locks and dams necessary for slackwater navigation. Under the river and harbor appropriation bill approved June 23, 1866, surveys of the Minnesota River were made, and a report of the results, together with plans and estimates for the improvement of the river, were submitted by Major Warren, January 21, 1867. This report can be found in Ex. Doc. No. 53, House of Representatives, second session Thirty-ninth Congress.

In it two modes of improvement were reported upon: one for a system of locks and dams, creating a slackwater navigation, and the other for one lock and dam at Little Rapids, and a yearly amount of work in removing snags, bowlders, and bars.

The first plan was estimated to cost \$775,000; the second plan was

estimated to have a first cost of \$97,500, and a subsequent annual cost of \$20,000.

By river and harbor appropriation bill, approved March 2, 1867, there was appropriated	\$37,500 00
By act approved July 11, 1870, there was appropriated	10,000 00
By act approved March 3, 1871, there was appropriated	10,000 00
By act approved June 10, 1872, there was appropriated	10,000 00
By act approved March 3, 1873, there was appropriated	10,000 00
By act approved June —, 1874, there was appropriated	10,000 00
Total	87,500 00
Total expended to July 1, 1874	76,095 53
Amount available	11,404 47

The only work accomplished has been the removing of bowlders, snags, and overhanging trees from Minnesota Falls to the lower rapids, except a space of about thirty-three miles extending up stream from St. Peter.

It will be seen that only a part of the second plan proposed by Major G. K. Warren was approved by Congress, no appropriation having been made for the lock and dam at Little Rapids. I think that experience has shown that the first plan (slackwater navigation) is the only true one for the permanent improvement of this river.

Before submitting an estimate of the cost of it, the detailed surveys of the sites of the proposed locks and dams ordered by second section river and harbor bill, approved June 23, 1874, must be made.

I would respectfully recommend that the sum of \$60,000 be appropriated for the proposed lock at Little Rapids, as this is common to both plans, and will very materially help navigation during low water.

While the removal of snags, bowlders, and overhanging trees is of great use to the navigation of the river, yet at low water it is now of no use, as boats cannot get above the Little Rapids.

Financial statement.

Balance in Treasury of United States July 1, 1873	\$5,000 00
Amount in hands of officer and subject to his check	6,379 72
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during the fiscal year ending June 30, 1874	9,975 25
Amount available July 1, 1874	11,404 47
Amount required for the fiscal year ending June 30, 1876	60,000 00

H 5.

EXAMINATION AND SURVEY OF GALENA RIVER TO THE UPPER BRIDGE AT GALENA, ILLINOIS.

UNITED STATES ENGINEER OFFICE,
Saint Paul, Minn., December 29, 1873.

GENERAL: I have the honor to make the following report of the result of the examination and survey of the Galena River, from its mouth to the upper bridge at Galena, Ill., made by Assistant J. D. Skinner, under my direction, during the months of August and September, 1873. I herewith submit Assistant Engineer Skinner's report to me. The tracings of the river, in four sheets, have this day been forwarded by express to your address. By referring to the tracings it will be seen that there is very little water flowing past the city of Galena during low water, quite insufficient to make any current which would scour out and carry

away any deposition of mud made during high water. Previous to the completion of the Illinois Central Railroad to Dunleith, on the Mississippi River, the river was kept open for navigation during low water by constant dredging. Shortly after the completion of the railroad to the Mississippi River, the dredging was discontinued, and as a consequence the river soon filled up with the washings from the high clay-banks. The opening of the cut-off between Harris's Slough and the Galena River undoubtedly backed up the water of the latter river and stopped the current, and much of the matter suspended in the water, before carried into the Mississippi River, is now deposited above the cut-off. The parties who made the cut-off thought that, by doing so, the water in the Galena River would be deepened by one foot, and they were right as to the immediate result, but they do not seem to have considered the result of stopping the current of the river above. At the time of the survey there was no perceptible fall of the river between the city of Galena and the cut-off, a distance of about four miles. From the cut-off to the Mississippi River there was a fall of 0.937 of a foot. By reference to the map it will be seen that the only way the river can be improved is by dredging, and taking some means to collect the matter brought down by the inflowing streams from the hills before it reaches the river. Small dams across the ravines seem to be the most economical method for the latter purpose. The dredging in the river above the cut off will be expensive, owing to the long towage to dump the dredged material. Owing to the abruptness of the river banks and the great rise of water during the high-water season, none of this material can be deposited in spoil banks, but must all be towed down and into the lower part of Harris's Slough. Were the quantity of water flowing past the city of Galena during low water sufficient for any purpose of scouring the bottom of the river, some good might be done by cleaning the cut-off, but as it is not, it does not seem worth while to make all steamers moving into the Galena River, on their way up and down the Mississippi River, take a long detour by cutting them off from Harris's Slough. Some little dredging is necessary in Harris's Slough, for which Mr. Skinner has made a separate estimate. The filling up of Harris's Slough below the cut-off will throw a large volume of water through the cut-off, and will, no doubt, scour out the bars in the Galena River below it. I would recommend the last plan proposed by Assistant Engineer Skinner; that is, to dredge to a depth of 6 feet above the cut-off, and to 4 feet below, to close Harris's Slough below the cut-off, thus throwing the whole volume of water of Harris's Slough through Galena River, and dredging a small amount at the head of Harris's Slough. Small dams of dry masonry backed with earth should be put across the three principal ravines. This would cost not less than \$400,000. Half the work could be done in one season and half the next.

It is hard to say how much the general commerce of the country would be benefited by the improvement of the Galena River; but there is no doubt that its improvement might greatly stimulate the local commerce. The country about the city of Galena is filled with farms, and when the Southern Wisconsin Railroad is finished, the city would be the shipping-point for a large quantity of lead and zinc ores and metals. Should Congress deem it advisable to improve the river, the sum of \$200,000 could be economically disbursed during one fiscal year.

I have the honor to be, very respectfully, your obedient servant,

F. U. FARQUHAR,

Major United States Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Report of Mr. James D. Skinner, Assistant Engineer.

UNITED STATES ENGINEER OFFICE,
Saint Paul, Minn., December 27, 1873.

COLONEL: I have the honor to submit the following report of a survey of the Galena River, in the State of Illinois, made by me under your direction, during the months of August and September, A. D. 1873. The main stream is formed by two forks, which have their confluence about three miles above the city of Galena.

The Illinois Central Railway follows the valley of the east fork, and the Galena and Southern Wisconsin that of the west fork. This road is graded and bridged, but not yet in operation.

Both streams take their rise in Southern Wisconsin. During low water the discharge of these united streams, measured just above Galena, is inconsiderable, amounting, by careful measurement at extreme low water, to 15.89 cubic feet per second, or 1,372,896 cubic feet per 24 hours.

This would be altogether insufficient to supply lockage, and, not to speak of other reasons, renders the use of a lock at the cut-off, hereafter referred to, impracticable.

At and below Galena there is virtually no current, the stage of the river being entirely the result of the height of water in the Mississippi River, the back-water of which, at its extreme height, extends two miles above the city of Galena.

The distance between extreme high and low water marks is 17 feet at the levee.

The cut-off, (see map,) situated about four miles below Galena, is a connection with Harris's Slough, (a portion of the Mississippi River at a point where it approaches within 250 feet of Galena River.) Here a small ditch was cut by some steamboat-men about three years ago, and the water at that point being a foot higher than that of the latter, soon forced a deep and permanent water-way, and through that opening a large amount of Mississippi water finds its way to the mouth of Galena River, changing the character of the water, and creating a strong current below the cut-off.

The necessary effect was to raise the water of the latter stream, above the connection, at least one foot, which gain, as the latter is wholly dependent on the Mississippi for its stage of water, is permanent.

Another result has been to fill up the lower portions of Harris's Slough, and at low water almost no water passes through it, as will be seen by reference to the map.

This can be permanently closed so as to entirely divert the water of Harris's and Key's Sloughs (see map) until it has reached a height of 10 feet above low water, (the height of the adjacent islands,) and this will greatly tend to cut out and deepen the channel, the bed of which, below the cut-off, is mostly of sand, and will render dredging in that part of the river mostly, if not wholly, unnecessary. The embankments closing this can be made from the material dredged from the upper river, which will seek a place of deposit, and will save three or four miles of towage for that portion which composes it. Its face can be thoroughly protected with riprap, an abundance of which is at hand, and its upper surface paved to an extent sufficient to protect the necessary portion from wash at high water.

The upper river is entirely different in character; the water is sluggish, muddy, and fetid; large amounts of deposits are annually swept down by storms, &c., from the steep hillsides, which form its banks, and out of the valleys, or coulees, which at intervals extend back into the country. The natural result has been that the river has been filled by the deposits from these sources to such an extent that in low water even the smallest steamboats cannot approach nearer than two miles to Galena.

Thirty years ago, from the most reliable information to be obtained, there was a depth of water in the basin (see map) of 10 feet; now it is a mass of mud virtually dry at low water, and the deposits have reached in places a height of 5 feet above low water.

The remedy for this after the necessary dredging has been done would be, first, a dam at Meeker street bridge to collect the silt from the upper river; second, similar dams across the mouths of the coulees discharging into the river, the deposits to be removed at proper periods; this would be gladly done by the proprietors of the adjacent vineyards and farms. With these precautions a number of years would elapse before a repetition of dredging would become necessary. This, however, when required, is the only way in which navigation can be maintained to the city of Galena. I herewith submit an estimate of the amount of dredging to be done to put the river in a navigable condition. This is based upon a width of 100 feet for a distance of 8,500 feet below the basin; at this point a sharp bend in the river necessitates a change of the channel. This can be made by cutting through the point (see map) and the material deposited in the present channel. Here a width of 200 feet has been given, and in all cases a slope of two upon one has been allowed for. Below this point a width of 150 feet has been given.

The estimate is based upon, 1st, a depth of 6 feet; this would be desirable in the upper river to allow for the unavoidable deposit; 2d, a depth of 4 feet throughout;

3d, a depth of 6 feet above cut-off and 4 feet below the same. Below the cut-off the river would in all probability make for itself a sufficient channel after the preliminary dredging had been done. A depth of 4 feet below the cut-off would be likely to meet the requirements of all boats that ply on the Upper Mississippi.

Owing to the character of the banks of the river and the causes which have filled it at present, all material dredged must either be deposited in the embankment closing Harris's Slough, at the cut-off, or towed below the mouth of the river and dumped into the Mississippi at a suitable point. The amount of excavation estimated above Green street bridge (see map) is believed to be unnecessary, as no boats have ever passed above that structure. The estimates above referred to are as follows, forty per cent. having in all cases been added to actual quantities:

Estimate of amount of dredging to be done in Galena River in order to give a channel-way from 100 to 150 feet wide, and 6 feet depth of water, as above described.

	Cubic yards.
In basin.....	62, 325
From basin to cut-off.....	484, 205
From cut-off to mouth of river.....	185, 220
Total.....	731, 750
Should river be dredged between Green and Meeker street bridges there will be added.....	93, 540
The same for four feet depth of water.	
In basin.....	46, 396
From basin to cut-off.....	260, 498
From cut-off to mouth of river.....	48, 343
Total.....	355, 237
Should river be dredged as above, add.....	60, 827
The same for 6 feet of water above and 4 feet below the cut-off.	
In basin.....	62, 325
From basin to cut-off.....	484, 205
From cut-off to mouth of river.....	48, 343
Total.....	594, 873
Dams across mouths of coulées.....	4, 867
Dam at Meeker-street bridge.....	1, 330
Riprap for face of embankment closing Harris's Slough at cut-off.....	750

HARRIS'S SLOUGH.

Amount of dredging necessary to render Harris's Slough navigable for boats plying to Galena.

Total dredging for 4 feet depth of water.....	51, 116
Total dredging for 6 feet depth of water.....	142, 762

RECAPITULATION.

Six feet depth.

731,750 cubic yards dredging, at 60 cents	\$439, 050 00
6,197 cubic yards masonry, at \$3.....	18, 591 00
750 cubic yards riprap, at \$2.....	1, 500 00
Total.....	459, 141 00

Four feet depth.

355,237 cubic yards dredging, at 60 cents	\$213, 142 20
6,197 cubic yards masonry, at \$3.....	18, 591 00
750 square yards riprap, at \$2	1, 500 00
Total.....	233, 233 20

Six feet depth above, and four below, cut-off.

594,873 cubic yards dredging, at 60 cents	\$356, 923 80
6,197 cubic yards masonry, at \$3	18, 591 00
750 cubic yards riprap, at \$2	1, 500 00
Total	377, 014 80

I hereto append a report on the commerce of the city of Galena, and its relations to the general business of the Mississippi River, kindly furnished me by M. Y. Johnson, esq., president of the Galena and Southern Wisconsin Railway, and a prominent business man of that place.

This gives full information on that subject.

Respectfully submitting the above, I have the honor to be, very respectfully, your obedient servant,

JAMES D. SKINNER,
Assistant Engineer.

Col. F. U. FARQUHAR,
Corps of Engineers, U. S. A.

Commercial statistics.

GALENA, ILL., September 20, 1873.

GENTLEMEN OF THE HARBOR AND RIVER SURVEY: You ask me to give you some statistics in regard to the business of the city of Galena. I cannot do this better than to give you a carefully-prepared statement, embraced in the foregoing memorial to Congress, with such partial reports as made by the Illinois Central Railroad Company as they appear in the monthly statements made by the company as to shipments on their road from the city of Galena, and the city weighmaster's report, made to the city council, as taken from the market-reports printed in the daily papers, viz :

The shipments during the month, as compared with the same month in 1871, will be interesting. They are as follows:

JANUARY, 1872.

		Cars.	Pounds.
Dressed hogs	head..	2, 940	24 489, 210
Mess-pork	barrels..	2, 765	46 884, 800
Lard	tierces..	907	18 334, 610
Bacon	packages..	394	11 206, 500
Lead	pigs..	3, 071	12 224, 100
Oats	sacks..	13, 693	110 2, 269, 800
Green hides	packages..	697	2 37, 900
Butter	do....	178	1 15, 140
Cattle	head..	36	2 36, 000
Pigs' feet .....	.....	1	1 14, 750
Zinc-ore .....	.....	21	420, 000
Sundries .....	.....	2	26, 960

JANUARY, 1871.

		Cars.	Pounds.
Dressed hogs	head..	3, 660	33 658, 075
Mess-pork	barrels..	1, 440	24 460, 800
Lard	tierces..	457	9 153, 970
Bacon	packages..	130	6 106, 110
Lead	pigs..	4, 618	18 331, 720
Lumber	M..	25+	5 100, 000
Green hides	bundles..	641	2 37, 060
Oats	sacks..	574	4 83, 100
Wheat	do....	495	4 66, 280
Barley	do....	138	1 19, 000
Butter	packages..	148	1 12, 070
Cattle	head..	184	10 180, 000
Merchandise .....	.....	...	120, 922

Two hundred and fifty cars, with 4,959,770 pounds of produce, were forwarded in January, 1872, while in the same month, in 1871, we find only 125 cars, with 2,329,107 pounds, a gain so far the present year of 100 per cent.

The tables show that January, 1871, shipped the greatest number of dressed hogs, but combining the four articles of the hog product, hogs, mess-pork, lard, and bacon, and we find that January, 1872, shipped 204,450 pounds more than the corresponding period last year; while in oats, we have the astonishing figures of 2,269,800 pounds against 83,100 for the same time, an increase of 2,184,700 pounds. For that matter, the month of January, 1872, lacked only 184,070 pounds (about 9 cars) of having forwarded as many oats as during the entire year of 1871. and had there been the needed supply of cars would have exceeded that of oats in said year.

This is encouraging, and offers greater reasons than ever why we should all unite in the efforts being made to *extend our railroad facilities* in the direction from whence these products come.

Besides the shipments, our grain-warehouses are full and will be overflowing when navigation opens. While this is true in grain, it is none the less an object of interest than that of mess-pork, bacon, lard, and lead that will then be on hand, showing further, that while we should increase our rail facilities, it is equally our duty to *improve the navigation of Galena River*. These two improvements (of rail and river) will so augment our commercial business as to compare favorably with towns of quadruple the population of ours. No town west of Chicago and north of Saint Louis is so favorably located as Galena to make a large commercial center, if our people will only improve the facilities nature has lavishly laid before them.

In connection with the above report of shipments for the month of January, we have the report of city weighmaster, Thomas McIntire, showing that 13,570 dressed hogs were weighed on the city scales during the same month. This does not include large lots bought at other places and delivered direct to the packing-houses.

The general markets during the past week with a very few exceptions were quiet. In groceries the demand has been but light, and chiefly for small assortments. Our wholesale grocers have on hand full stocks, and are receiving daily additions, preparatory to the spring trade.

There were 13,570 dressed hogs weighed in Galena during the month of January. There have been a little over 26,000 weighed on the public scales here this season. This does not include the hogs slaughtered by J. M. Ryan, nor those packed here which were bought in other markets. The total number of hogs handled in Galena this season will not fall far short of 50,000.

I herewith present you with some details of statistics, taken from the United States Census of 1870, of the counties of Grant, Iowa, and La Fayette in Southern Wisconsin, and Jo Daviess County in Illinois, the surplus products of which find a market or shipment from the city of Galena.

This region is directly tributary to Galena.

	Counties in Wisconsin.	Jo Daviess County,
Acres of improved land.....	647, 338	156, 507
Present value of farms.....	\$30, 163, 393	\$8, 831, 353
Value of crops and productions.....	\$8, 767, 874	\$2, 538, 195
Value of live-stock.....	\$5, 524, 352	\$1, 611, 521
Value of animals sold for slaughter.....	\$2, 201, 656	\$807, 576
Bushels of wheat raised.....	2, 189, 809	282, 758
Bushels of corn raised.....	3, 744, 643	1, 226, 326
Bushels of oats raised.....	3, 756, 173	874, 016
Bushels of barley raised.....	160, 985	22, 889
Bushels of potatoes raised.....	631, 485	201, 015
Bushels of flaxseed raised.....	69, 395	9, 344
Flax raised.....	84, 523	32, 476
Tons of hay.....	116, 547	34, 372
Zinc-ore.....		300, 000

The surplus of these products find a market in the South, and, with the completion of the Galena and Southern Wisconsin Railroad, now in process of construction, (and thirty miles nearly completed,) following the fourth principal meridian to the watersheds of the Wisconsin River, and then running along the military ridge to the city of Madison, Wisconsin, you at once open up to the commerce of the Mississippi River a country unsurpassed in fertility, productions, and mineral wealth.

In the single article of zinc-ore, last year there was shipped over the Mineral Point Railroad to Warren, and thence over the Illinois Central Railroad to the La Salle Zinc Works, 15,000 tons. This zinc-ore is hauled on wagons at an expense of \$4 a ton from the mines to the railroad, a distance of from eighteen to twenty-two miles. With our road completed running direct to these mines, if we could be assured of the navigation of Galena River, this article alone would furnish thousands of tons for transportation to the coal-fields of Missouri and Illinois to be smelted.

To be profitable it must seek a cheaper mode of transportation than by rail, and in return this vast region is to be supplied with coal when it can be furnished by cheap water-transportation.

The population of the city of Galena in the present limits is nine thousand. There has been but little increase in population for several years, until within the last two years. Owing to local causes a more hopeful feeling has prevailed, and the business prospects of the city have greatly improved, while the business interest of the city has been greatly injured and its prosperity retarded by the uncertainty of navigation on said river. But with our railroad completed, penetrating Southern Wisconsin, and our river made navigable, we would be assured of our former prosperity.

It was not uncommon a few years ago to see from twelve to fifteen steamboats a day at our wharf; from various causes, particularly the filling up of our river from the washings and deposits occasioned by the cultivation of the lands along the banks, and the construction and leaving unprotected the railroad embankments, that to-day it is impossible for steamboats to reach the landing, where a few years ago there was an abundance of water to accommodate any boat that navigated the Upper Mississippi.

This is no doubt produced in part from the cut-off leading to the Mississippi. As in ordinary water the current flowing from the Mississippi into Galena River produces a strong current below the cut-off, so as to generally keep that part in boating order, while above the cut-off there is little or no current up to and above the city, thus serving as a basin to collect deposits and fill up the river, which has been accumulating for years, but not regarded until it became a positive obstruction to navigation.

With the river cleared out and the railroad companies required to riprap at exposed points, I think all obstruction from deposits would be entirely removed, particularly so if the city authorities (as is being agitated) would allow a dam to be thrown across the river at Meeker street, above navigation, to create a water-power that could be so constructed as at certain periods, when the Mississippi River was at low stage, the water could be let off, and wash out the channel from all obstructions.

The dam would serve an additional purpose as a reservoir to collect the deposits before it could run in the river below and obstruct it.

In this connection, as you ask any practical suggestion, I think if the cut-off is not filled up and the river restricted to its original channel, that there should be thrown out from Harris's Slough a wing-dam to throw a much larger body of water from the Mississippi River into Galena River, the tendency of which would be to increase the depth of water above the cut-off. But our people are satisfied with any plan that may be adopted to remedy the evil.

Yours, respectfully,

M. Y. JOHNSON.

H 6.

RED RIVER OF THE NORTH, FROM MOOREHEAD, MINNESOTA, TO PEMBINA, DAKOTA.

UNITED STATES ENGINEER OFFICE,
Saint Paul, Minn., March 4, 1874.

GENERAL: I have the honor to make the following report of the results of a survey of the Red River of the North, from Moorehead, Minn., to Frog Point, Dak., and of an examination from thence to Pembina, Dak. The part surveyed contains all the serious obstructions to navigation in that part of river ordered surveyed by act of Congress approved March 3, 1873, and the detailed survey of this part took all the short season after the subsidence of high water. The surveying party was under the charge of Assistant Engineer D. W. Wellman, who was assisted by Sub-Assistant C. F. Hollingsworth and Recorder Hart Vance.

I. The Red River of the North has its head at the junction of the Bois de Sioux and Otter Tail Rivers, on the western boundary of the State of Minnesota. Its general direction is almost due north, and within the territory of the United States the distance between its head and the northern boundary of the United States is 197 miles. The course of the river in the same limits is more than twice as long. It is a sluggish, tortuous stream, the current, except at the rapids or chutes, being hardly one mile per hour. It flows through a very flat prairie, between clay banks, varying from 20 to 60 feet high. This prairie rises

from the top of the river-banks very slowly, about 2.5 feet per mile, to the east and west, and falls towards the north about 0.7 foot per mile. At Moorehead the river-banks are $33\frac{1}{2}$ feet high, at Frog Point (the end of the survey) 61 $\frac{1}{2}$ feet, and at Pembina about 50 feet. The area within the territory of the United States drained by the Red River is about 32,000 square miles. The annual rain-fall is very small.

The following are the measured rain-falls for 1873, at the several posts about the Red River Valley :

Fort Abercrombie, 11.42 inches of rain, but snow-fall not measured. Average snow-fall for 12 years, 4 inches per year.

Fort Pembina, 14.185 inches. Average for three years, 13.16 inches.

Fort Wadsworth, 29.45 inches. Average for 5 years, 18.95 inches.

Fort Totten—

Besides the Bois de Sioux and the Otter Tail Rivers, which form the head of the Red River, the principal tributaries within the United States from the west are the Wild Rice, Cheyenne, Elm, Goose, Turtle, Big Salt, Little Salt, and Pembina Rivers, and on the east the Buffalo, Wild Rice, Sand Hill, Red Lake, Snake Hill, and Two Rivers. At Moorehead the stream is, at low water, 100 feet wide, and at Frog Point, after flowing a distance of 122 miles, about 160 feet. The river from Moorehead to the head of Goose Rapids is 98.062 miles long, and falls 50.658 feet, or about $\frac{1}{2}$ foot per mile. The main rapids are 0.928 of a mile long, and the fall in that distance is 4.6 feet. From thence to the end of the survey, 21.031 miles, the fall is 16.569 feet, or 0.77 of a foot per mile.

Immediately adjoining the banks of the river is considerable timber; more on the east bank than on the west, owing to the destructive annual prairie fires sweeping along from the Dakota plains. The timber is oak, basswood, and poplar. The water is muddy from the washings of the clay banks, but pleasant to the taste, notwithstanding the Big and Little Salt and the Turtle Rivers are very brackish. The annual spring freshets are variable in duration and height. They are caused, not from an excess of rain-fall at the headwaters, but from ice-gorges formed at various points of the river, owing to the ice in the upper part of the river breaking up before that in the lower. At highest water the current is very small, hardly perceptible, but when the ice-gorges give way there is for a short time a current of great velocity, which often does great damage to the banks. The difference of level between high and low water marks at Pembina is 45 feet, at Moorehead about 36 feet.

The total fall of the river from Moorehead to Pembina is 116.3 feet, which would show that the average fall per mile of the river below Frog Point is very small, not exceeding three-tenths of a foot per mile.

The valley of the Red River is very sparsely settled. Along the immediate banks the principal settlements in the United States are, Breckinbridge, Minn.; Macauleyville, Minn., (opposite Fort Abercrombie;) Moorehead, Minn.; and Fargo, Dak., on the opposite bank of the river at the Northern Pacific Railroad crossing; Georgetown, Minn., about 15 miles below Moorehead by land; Frog Point, Dak., (the head of low-water navigation;) Grand Forks, Dak., opposite the mouth of the Red Lake River, and Pembina, Dak., $2\frac{1}{2}$ miles south of the boundary. There are some few farms, but very few.

II.—OBSTRUCTIONS TO NAVIGATION IN THE RIVER.

The obstructions to navigation are not very formidable, except at one place, Goose Rapids. Commencing at Moorehead and going down stream the obstructions are as follows, (see accompanying tracings:)

Obstructions between Moorehead and Goose Rapids along the banks and in the channel of the Red River of the North.

Position.	Snags.	Overhanging trees.	Fallen trees on bank.	Miscellaneous.	Trees in water.	Remarks.
Between Moorehead and Cheyenne River.	41	61	2	3 land-slides, small	9	
Between Cheyenne River and Georgetown.	8	1	1	do.....	4	
Between Georgetown and Elm River.	9	2	2	1 land-slide, small.	1	Nine bunches of loose brush caught on bottom.
Bar $\frac{1}{2}$ miles below Goose River.	.....	.....	.....	1,000 cubic yards.	.....	Dredging.
Two miles below Goose River.	.....	.....	.....	4 cubic yards.	.....	Boulders.

At Goose Rapids the river falls 4.6 feet in 4,900 feet, (the length of the main rapids.) The channel is filled with boulders, which render the navigation impossible at low water. Last season the parties owning the steamboats navigating the river constructed some wing-dams, so as to deepen the water over the worst places in the rapids. The result was plenty of water, but running at such a velocity as to render necessary the use of warping hawsers to pass steamboats from the foot to the head of the rapids. Below Goose Rapids the obstructions are as follows :

Obstructions between Goose Rapids and Frog Point, Red River of the North.

Position.	Cubic yards
Spar Chute.....	11,388
Flat-boat Chute.....	3,375
Bear Chute.....	10,170
Campbell's Rock.....	10
Two Willow Rock Points.....	2,064
Five Rocks.....	10
Dry Tree Chute.....	14,450
Isabella Island.....	12,420

III. The following plans and estimates are submitted for removing or overcoming the above-mentioned obstructions to navigation :

Above Goose Rapids the snags should be removed, the overhanging trees cut down, and the mud-lumps dredged out, all of which would cost \$4,428.

To overcome the fall at Goose Rapids, I would recommend a lock and dam, the lock to be placed in the second neck of land, (see tracing on large scale,) and the dam in the third reach below the foot of the rapids; the lock to be 50 by 150 feet in plan, and a lift of 6 feet; the floor and gates of the lock to be of timber and the walls of concrete masonry.

Owing to the remoteness of the locality and the consequent cost of labor and materials, the lock would cost not less than \$175,000, and the dam not less than \$10,000.

Between the site of the proposed lock and Frog Point, the obstructions could be removed by dredging the bars and removing the boulders. The cost of dredging would be \$32,380.20, and of removing the boulders, \$500. I do not make any estimate for any work below Frog Point, as the examination was not detailed enough, but there are no serious obstructions. I would recommend that the survey be continued to the northern boundary of the United States.

Summary of estimates.

Above Goose Rapids	\$4, 428 00
Lock and dam to overcome fall at Goose Rapids.....	175, 000 00
Between Goose Rapids and Frog Point	32, 830 20
Total	212, 308 20

IV.—COMMERCE OF THE RED RIVER.

Last season there were three steamboats plying on the Red River between Moorehead and Fort Garry, Manitoba, and two more are to be placed on the route next summer. Besides these steamers there are many flat-boats, which carry large amounts of freight.

The business on the river is principally carrying supplies for the settlements in Manitoba and bringing back furs. The amount of freight carried down-stream last summer was 16,000 tons, and the amount up-stream hardly exceeded 300 tons. As the country is settled the traffic on the river will increase. A railroad is projected and located on the east of the river. It is generally between ten and twenty miles away from the river, and is finished to the crossing of the Red Lake River. It is supposed it will be finished to Pembina next season. This will stimulate immigration, and as farm-products can be transported more cheaply by river than by rail, a considerable increase of traffic on the river may be looked for during the next few years.

V. No detailed estimate of the cost of the lock and dam are submitted, as before such estimates can be furnished there must be borings made and other details determined, which can be done after Congress determines on the improvement of the river. I would, therefore, recommend a first appropriation of \$40,000 to be used in removing snags, bowlders, and overhanging trees, and to make the detailed examinations of the sites of the proposed lock and dam. Those interested in the navigation of the Red River would much prefer, if only a part of the desired improvements can be made during the coming season, that the obstructions above and below the rapids should be removed first, as they can afford to build the temporary wing-dams at the rapids, but cannot afford to remove the bars and rocks above and below.

I forward by express to-day, to your address, seven sheets of tracings, showing the river as far as surveyed, and one on a larger scale of the vicinity of Goose Rapids.

Hoping that this report may meet with your approval, I have the honor to be, very respectfully, your obedient servant,

F. U. FARQUHAR,
Major United States Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

H 7.

SURVEY OF THE UPPER MISSISSIPPI RIVER.

UNITED STATES ENGINEER OFFICE,
Saint Paul, December 22, 1873.

GENERAL: I have the honor to transmit herewith the report of Assistant Engineer J. D. Skinner, who made the examination, under my direc-

tion, of the results of an examination of the Mississippi River between Saint Cloud and the Falls of Saint Anthony. The report is accompanied by tracings, showing the parts of the river where obstructions to navigation are said to exist. It was unfortunate that this examination could not have been made before the river was filled with ice-gorges, which in all cases caused an increase of depth of water in the river immediately above them, and prevented as thorough an examination as could have been made at low water during the fall months.

As Mr. Skinner remarks, there may be many other obstructions in the river, between the above-mentioned points, besides those mentioned in his report, as he had to rely on the pilots to show him where the river needed improvement.

It is of importance that a complete survey of the navigable portions of the Mississippi River above the Falls of Saint Anthony should be made, so that when information is required it can be given from reliable sources.

There is no doubt that the improvement of the Mississippi River at the points mentioned in Mr. Skinner's report will greatly aid navigation, and boats plying on the river will give a ready means by which the farmers living on the west bank of the river can carry their produce to a market.

The amount estimated, \$43,034.75, as the cost of improving the river at the points mentioned in Mr. Skinner's report, is none too large, and can be usefully expended during the fiscal year ending June 30, 1875.

The papers accompanying letters dated "Office of the Chief of Engineers, Washington, D. C., November 19 and December 6, 1873," are herewith returned.

Hoping that this may meet with your approval, I have the honor to be, very respectfully, your obedient servant,

F. U. FARQUHAR,
Major of Engineers.

Brig. Gen. A. A. HUMPREYS,
Chief of Engineers, U. S. A.

Report of Mr. James D. Skinner, Assistant Engineer.

UNITED STATES ENGINEER OFFICE,
Saint Paul, December 20, 1873.

SIR: I have the honor to submit the following report of an examination of the Mississippi River between Minneapolis and Saint Cloud, made by me in pursuance of instructions received from you on the 1st instant.

Six portions of the river, where navigation by a small class of steamboats had in former years been impeded during low water, were surveyed, and careful soundings taken through the ice. The season was particularly unfavorable for the work, the river, owing to the gorging of the ice upon the rapids, varying from one to seven feet above low-water mark, and being filled to the bottom with anchor-ice. No definite low-water mark could be obtained, and the information gained from pilots and rivermen, who knew certain rocks and localities and the usual depth of water at the lowest stage, has been the guide to the notes on the plans hereto attached, which give the height of the water at the time of the survey above the most reliably ascertained low water.

The difficulties to be removed in order to render navigation practicable at low water, consists of bowlders, large and small, mixed with gravel; these in all but one instance, that of the Thousand Islands, form the bed of the river, and the deepening of the channel on the rapids will require dredging.

In some cases large rocks are imbedded in the river bottom, projecting sufficiently above the average bed to become obstacles to the passage of boats; these and the larger bowlders can be easily removed at low water.

Thorough soundings have been taken, and the localities surveyed have been connected with the lines of the Government survey.

A more thorough survey than is practicable at this season of the year may develop other obstacles, but the points described below are the main and recognized places where boats in former years have experienced difficulty.

At Coon Rapids (see plan No. 1) there is a strong current, the fall of the water at time of survey being at the rate of 1,177 feet in a distance of 1,000 feet. The bottom consists of small bowlders and gravel, and at the points marked on the plan are large bowlders imbedded in the river bottom. To give a depth of 4 feet and a channel-way 200 feet wide will require the removal of 14,000 cubic yards.

Two miles below Anoka (see plan No. 2) a rocky reef or bar puts out from the east bank and encroaches upon the channel. The removal of part of this and the necessary deepening as above will require 4,800 cubic yards of excavation.

At Battle Rapids, below the town of Monticello, (see plan No. 3,) the bottom is of a similar stony character, and will require excavation to the amount of 4,440 cubic yards.

Cedar Island Rapids (see plan No. 4) has a bottom of the same character, and the necessary excavation will amount to 9,450 cubic yards.

At the "*Thousand Islands*" the river suddenly widens to the extent of three-fourths of a mile, and is filled with islands of varying dimensions, the larger proportion being small. The bottom is, throughout, sand. The annexed plan, marked No. 5, shows the channel on the west side of the river and the location of the adjacent islands. No dredging will be needed here. Two wing-dams, one of 450 feet and the other of 650 feet in length, will sufficiently divert the water into the main channel to insure the necessary depth.

Rocky Point, just below Saint Cloud, (see plan No. 6,) is a bar between two islands, over which it is necessary to pass in following the eastern channel, the western being much embarrassed by boom-piers. The excavation here will amount to 4,500 cubic yards; and one large rock lying on the east side of the channel may require removal by blasting.

The summary which follows gives an estimate of the cost of improving the river at the points above named, a channel-way 200 feet wide and 4 feet deep to be obtained at low water.

SUMMARY.

	Cubic yards.
Excavation at Coon Rapids.....	14,000
Excavation two miles below Anoka.....	4,800
Excavation at Battle Rapids.....	4,440
Excavation at Cedar Island Rapids.....	9,450
Excavation at Rocky Point.....	4,500
Total excavation, bowlders and gravel.....	37,190

ESTIMATE.

37,190 cubic yards, as above, at 75 cents	\$27,892 50
46 cubic yards rock requiring blasting, at \$5	230 00
1,100 linear feet wing-dams, at \$10	11,000 00
Total	39,122 50
Add 10 per cent. for contingencies.....	3,912 25
Total	43,034 75

During the present season one steamboat has been plying on that portion of the river above described, and another is now being constructed. Could these boats run regularly throughout the season, a great relief would be afforded to the inhabitants of the west bank of the Mississippi River between Minneapolis and Sauk Rapids. The country, unlike the eastern side, is a rich one, well cultivated, and producing a large amount of grain. The "*Big Woods*" come to within a short distance of the river at different points and will furnish a large amount of wood for fuel; the transportation of this alone would give a large business to a line of boats.

There is no railroad on the west side, and that on the east side is at a considerable distance from the river for most of its length, and is difficult of access.

The reduction of freight on supplies for this region, and on its products of wood, grain, and flour would be a necessary result of the existence of uninterrupted river navigation.

All of which is respectfully submitted, by your obedient servant,

JAMES D. SKINNER,
Assistant Engineer.

Col. F. U. FARQUHAR,
United States Engineer Corps, U. S. A.

APPENDIX I.

ANNUAL REPORT OF COLONEL J. N. MACOMB, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1874.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., September 9, 1874.

GENERAL : I have the honor to submit herewith the annual reports upon the several works in my charge during the fiscal year ending on the 30th June, 1874. There is accompanying each report a financial statement showing the amounts received, expended, and required for each work.

All of which is respectfully submitted.

J. N. MACOMB,
Colonel of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

I 1.

IMPROVING UPPER MISSISSIPPI RIVER.

This work was carried on under the immediate charge of Capt. J. B. Davis, whom I engaged for this duty on account of his knowledge as a river expert. His report, covering all operations for the fiscal year ending June 30, 1874, is herewith submitted as giving information in detail.

It will be seen by the accompanying financial statement that the amount expended during the fiscal year ending June 30, 1872, was \$22,656.62, a portion of the appropriation of \$25,000 having been expended for repairs toward the end of the preceding fiscal year.

The aid rendered to the navigation by having the Government steamer Montana on the river, to dredge sand-bars and remove the few snags occasionally found in the Upper Mississippi, is such as to justify the asking of the annual appropriation to enable us to render such temporary aid in advance of the more permanent relief which it is hoped may be afforded by a system of improvement expected to be developed from the surveys authorized at the close of the fiscal year and now in progress. It is for this reason only that so small an appropriation is considered sufficient for the present.

Some further permanent improvement will be effected toward the close of the present working season, by removing rocks from the vicinity in which such work was begun last November.

Financial statement.

Balance in Treasury of United States July 1, 1873.	\$25,000 00
Deduct amount expended in last fiscal year.	2,527 30
Amount appropriated by act approved June 23, 1874.	25,000 00
Amount expended during the fiscal year ending June 30, 1874.	22,656 62
Amount available July 1, 1874.	25,019 99
Amount required for the fiscal year ending June 30, 1876.	25,000 00

Report of Captain John B. Davis.

ROCK ISLAND, ILL., December 5, 1874

COLONEL: I have the honor to submit herewith my report on the operations of the United States steamer *Montana* in improving the Upper Mississippi River during the working season of 1873.

The *Montana* left Rock Island on the 2d of July for Saint Paul, with instructions from you to make a careful survey of Harper's Slough, Allamakee County, Iowa, on our way up, and report as to the practicability of making a channel through that slough for the navigation of steamboats with the means at our command. The survey was made accordingly on the 5th of July, and a report sent you in regard to same, showing it to be impracticable. (See letter of Colonel Macomb to Chief of Engineers, United States Army, dated 5th August, 1873.)

Arrived at St. Paul on the 8th. The river being too high to do anything in the way of dredging, we fitted up a pile-driver, and commenced driving piles at Newport Slough, nine miles below St. Paul, with a view to building a jetty for the purpose of turning the water from the slough into the main channel of the river. We cut cotton-wood piles and commenced driving them but soon found that the hammer of our pile-driver was too light to drive the piles deep enough to hold, and therefore went to St. Paul and procured a heavier hammer. We then commenced work at Pig's Eye Island, five miles below St. Paul, and built a jetty from the head of the island to the eastern shore, closing off the eastern side of the island entirely and turning the water to the western side. We then proceeded to Rollingstone Bar and built a jetty part of the way across the head of the slough, leaving room next to the western shore for the lumber-men to run their logs through.

We now found it absolutely necessary to procure better pile-drivers to prosecute our work, and consequently chartered two good pile-drivers, which were kept in use until November 5.

We dredged out a small island in Rollingstone Bend that was 120 feet long and 20 feet wide, removing it entirely. This island, being in a narrow part of the river, was greatly in the way of rafts. It was just above Fountain City, Buffalo County, Wis.

According to instructions from you, we then proceeded to De Soto, Wis., and dredged the bar in front of that town, leaving more water than there was in the main channel at that time. Report submitted to the Chief of Engineers, United States Army, September 3, 1873.

We then built a jetty at the head of Betsy's Slough, leaving room for the rafts to go down the western shore, just above Winona, Minn.

These jetties were built by driving piles close together and then placing two-inch plank on the up-stream side of them and down to the sand.

Finding that the jetty at Pig's-Eye had partly given way, we returned to that point and concluded to build a wing-dam there, and went to work driving two tiers of piles 9 feet apart and filled in with willow-brush and sacks of sand on top to weight it down. This work requires considerable time and labor, but we finished it, making a wing-dam 600 feet in length, 9 feet wide, and from 6 to 10 feet deep. This dam, together with the jetties, improved the channel considerably this season, but will show more clearly next season after the high water has acted upon the sand-bars.

It is the opinion of a majority of the steamboatmen that this is the proper plan of improving the river.

We worked at Pig's-Eye until the ice drove us away.

On our arrival at Rock Island, according to your instructions we proceeded to the mouth of Edwards's River, near New Boston, Ill., where yourself and Assistant E. F. Hoffman surveyed a dangerous rock lying in the middle of the river that had sunk two or three steamers and badly injured several others. It was determined to remove the rock by blasting, so we returned to Rock Island, built a tripod, and procured tools and other material for that purpose. On the following day we returned to the rock and succeeded in removing it, the work being done under the immediate supervision of yourself and Assistant Hoffman.

The steamers *Montana* and *Caffrey* were laid up in Rockingham Slough on the 17th of November, just in time to escape the ice.

The annexed summary will show the amount of work for the season.

The following is a summary of work performed during the working season by the steamer *Montana* in fiscal year ending June 30, 1874:

9 steamers and 2 rafts pulled off sand-bars.

3 snags and 2 stumps extracted.

16 leaning trees removed.

797 piles driven.

Built one wing-dam and two jetties.

Removed small island by dredging, and spent eight days in various localities dredging out channels.

Removed one large rock.

Run 2,263 miles in prosecution of above work.

I remain, very respectfully, your most obedient servant,

JNO. B. DAVIS.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

I 2.

IMPROVING DES MOINES RAPIDS, MISSISSIPPI RIVER.

This work has been well advanced during the year under the immediate care of Capt. Amos Stickney, Corps of Engineers, United States Army, whose report, to which I beg to refer for information in detail, is herewith submitted.

By this it will be seen that on the 25th of August, 1873, the masonry of middle lock was finished, and the excavation in prism of canal in the lock-section completed, including building of slope-wall within the lock-section where the embankment was sufficiently settled to receive it.

The sluices for regulating height of water in the canal were well advanced, the one at middle lock being nearly completed at end of fiscal year. It is expected to finish them early in current fiscal year.

The masonry at lower lock was also completed in August, 1873.

A favorable contract was made with Messrs. J. W. Kittle & Co., for "labor on guard-lock, section work, and channel excavations," the Government having assumed the conduct of the uncertain element of cofferdams, thus leaving a definite work for the contractors to execute. This arrangement has worked satisfactorily and has resulted in a great economy. The contractors finished the rock excavation in the channel of approach to head of canal, and would have completed the excavation of channel below lower lock had not high water flooded our lower cofferdam early in March last.

The scene of work was then changed to Sandusky pit, and continued to end of the year, with a certain prospect of completing that section of excavation at an early day.

The drainage was effected by a ditch in the bottom of the canal which enabled us to dispense with pumping, to a great extent, in the Sandusky pit and above.

Excavation for foundation of guard-lock was completed early in June, 1874.

The wall of masonry extending up from the outer wall of guard-lock and around the head of the great embankment, was built up above ordinary low water, so that it can be completed without further need of cofferdam. The work as far as done was protected by the cofferdam which was built for channel excavation.

It is supposed that the work of building the guard-lock will require about a year.

It appears that the open-market purchases of stone have been at prices more favorable to the Government than were the former contracts, and that the result of carrying on the work of the class required in this canal by hired labor under the immediate supervision of the engineers is advantageous and economical.

By the accompanying financial statement it will be seen that, after expending the funds in hand, the amount required for completing this great work is estimated at \$480,000.

It is confidently believed that an appropriation of that amount made so as to be available with the opening of the working season, in March, 1875, will lead to the completion of the work in the course of that year.

Financial statement.

Balance in Treasury of the United States July 1, 1873.....	\$400,000 00
Amount in hands of officer and subject to his check, (including \$18,230.12 percentage due on contracts not yet completed).....	66,300 88
Amount appropriated by act approved June 23, 1874.....	400,000 00
Amount expended during the fiscal year ending June 30, 1874.....	344,987 18
Amount available July 1, 1874.....	505,807 10
Amount required for the fiscal year ending June 30, 1876.....	480,000 00

Report of Capt. Amos Stickney, Corps of Engineers.

UNITED STATES ENGINEER OFFICE,
Keokuk, Iowa, August 31, 1874.

COLONEL: I have the honor to make the following report of the operations on the work of the improvement of the Des Moines Rapids of the Mississippi River, for the fiscal year ending June 30, 1874.

On the 1st July, 1873, there remained on hand from the last year's appropriation, \$66,300.88. The amount appropriated by act of Congress approved March 3, 1873, was \$400,000.

The project for carrying on the work during the year was as follows: To finish the masonry of the middle and lower locks; to build and bail by hired labor the necessary coffer-dams at both ends of the canal, to facilitate the excavation of the channel at the entrance; to construct by hired labor sluices at the middle and lower locks, purchasing the necessary material in open market; to complete by contract labor, as near as possible, the earth and rock excavation of the canal, and channel at entrances, and build as much of the riprap wall as could be done with the suitable stone taken from the excavations.

The work in progress at the beginning of the year was the construction of the middle lock, lower lock, and delivering of stone and cement for same. The work on the middle lock was being performed under the contract of Willard Johnson, and was continued up to August 25, 1873, at which time the masonry of the lock was finished, the excavation in the prism of the canal above the lock, in the lock-section, completed, and all the slope-wall laid within the lock-section where the embankment had settled and was sufficiently firm to receive it.

The stone for completing the lock and slope-wall was furnished under the contract of Messrs. Wells, Timberman & Co., of Keokuk, Iowa, dated September 4, 1872. This stone was furnished from the Sonora Quarry, and is much superior to either the Balingier or Tobie Quarry stone. There was an unavoidable delay in the delivery, as the stone required for the lock-walls was all dimension-stone and main-wall coping. Magnesian-limestone quarries will not yield stone of a special size without much waste, and consequent delay.

The cement was furnished under the contract of Mr. James Clark, of Utica, Ill., dated September 25, 1872, a sufficient quantity of which had been delivered prior to June 30, 1873, to complete the work, so no deliveries were made during the present year under his contract.

The project having been approved, and authority granted to construct a sluice for wasting the surplus water discharged during heavy rains, into the canal between the middle and guard locks, the work was undertaken and prosecuted entirely by labor employed by the United States.

The location of the sluice required the removal of nearly all the stone remaining over from constructing the lock before any excavation could be made. This was done during the winter of 1873-'74.

The necessary force was employed. Excavation for the sluice and dressing stone began in March, and on the 23d of March laying of the sluice-wall commenced, and the work progressed favorably.

There has been employed in connection with the sluice-work, a force of laborers completing the slope-wall about the lock, grading, and macadamizing the space between the sluice-wall and lock-wall, and between the lock-wall and canal-embankment on the outside.

The stone to complete the sluice and vertical walls, in excess of that remaining on hand, was purchased from Messrs. Wells, Timberman & Co., of Keokuk, Iowa, in open

market, and was delivered by them from their quarry at Sonora, and a commendable degree of energy and promptness was displayed in the delivery.

The work on the lower lock was in progress under the contract of Dull & Williams, and the final estimate was given the contractors August 23, 1873.

The work consisted in breaking a small amount of macadam, laying flagging around the gate recesses, and coping on the upper vertical walls. This finished the masonry of the lower lock, and left at this point only a small amount of work in finishing slopes, grades, &c., which could not well be done at this time. In November began the work of excavating for the sluice by hired labor. This work was carried on with a small force until March, 1874, when work was stopped a few days because of a sudden rise in the river. In May it became necessary to place a steam-pump at the upper end of the sluice, so great was the seepage of water through the banks. Since the erection of the pump there has been no interruption to the work. On account of difficulty in finding room for the deposit of material excavated, a little more time and some additional expense has been incurred in this part of the work.

At the end of the year about three-fourths of the excavation was completed, and as the delivery of stone commenced a small force began cutting. The laying of stone in the sluice-walls began on the 15th of June, and has continued satisfactorily without interruption.

The present season has been unusually favorable, and if nothing serious happens to interrupt the work for a few weeks longer the sluice-walls will be completed, and all work remaining to be done to complete the lock-banks and grounds, such as building a few yards of slope-wall and breaking macadam, will be done this season.

On the 21st of July, 1873, proposals were opened for performing the labor on "guard-lock, section work, and channel excavations."

Proposals were received from—

- | | |
|------------------------|-----------------------|
| 1. { J. K. Hornish, | 4. Samuel G. Bridges. |
| { John Adair McDowell. | 5. J. W. Kittle & Co. |
| 2. Guy Wells. | 6. George Williams. |
| 3. L. L. Hine. | 7. Willard Johnson. |

J. W. Kittle & Co. being the lowest responsible bidders, the work was awarded to them, but owing to the strong opposition made by competing bidders, the contract was not awarded to them till August 22, and they were unable to get to work until the 2d of September. In the mean time, a force of Government laborers were engaged in building a coffer-dam around the proposed channel excavations at the head of guard-lock, and another force in stopping the leak through the bed-rock of the river under the embankment at station 66.50, and opening the drains and cross-banks through the prism of canal from Nashville to Price's Creek, to facilitate the drainage of the work, and if possible avoid the expense of pumping. These side operations by Government laborers were all finished before the contractors were ready to begin their work, so that by the 2d of September the coffer-dam was finished and pumped, and there was nothing to delay Messrs. Kittle & Co. going to work at once.

During the months of September and October, 1873, the contractors succeeded in getting fairly to work; their plant of two narrow-gauge locomotives and fifty cars, rails, ties, &c., was received, and the work of excavation in the channel above guard-lock proceeded, but not as rapidly as it should. Strong hopes were entertained that the work on that particular portion of the improvement would be finished by the end of November, so that the pumping machinery and contractor's force could be moved to the coffer-dam at lower end of canal, and finish that excavation before the spring floods. But the work did not progress with the rapidity that could have been desired, and, on the 15th of November, 1873, orders were received from Washington to widen the excavation 40 feet at the lower end of the new channel, and continue the same up to the guide-pier at the head of the channel. This necessarily delayed the completion of the work, but the contractors placed all the men they could work upon this new excavation, and removed the material as fast as possible. During this time, more men being available than could work to advantage in the channel, a force was placed at Price's Creek, at Sandusky Pit, and upon a couple of cross-banks, so as to push the whole work toward completion wherever possible. During the following month of December, 1873, work progressed fairly until about the middle of the month, when a severe storm flooded the coffer-dam and canal prism, stopping all operations for a week, and it was not until the 12th of January, 1874, that the excavation of the new channel was completed, the pumps stopped, and the coffer-dam flooded. During the balance of the month of January, 1874, the contractors were engaged in removing their plant from Nashville to the coffer-dam at lower lock, the Government having already transferred the pumps to that dam, and being engaged in pumping it out. By the 28th they were enabled to get to work with a small force, and this they gradually increased as the dam became drier, and during the month of February, 1874, they did some very good work.

March 2, however, their men struck for higher wages, and March 4 the river rose so

high that in order to save the coffer-dam it was found necessary to cut it and allow it to fill. This, of course, stopped all operations in channel excavation for the time being, and the dam is still flooded.

By the 11th of March the contractors, with commendable energy, had organized another force, and removing half of their machinery to Sandusky Pit, (the other half being taken to the guard-lock,) they resumed work in that pit energetically.

During the months of April, May, and June the contractors have worked steadily with a fair force in the Sandusky pit, and give evidence that in a few weeks that portion of the improvement will be finished. While the excavation proper was being pushed through this pit, a drain 2 feet below grade and 12 feet wide was excavated through the center of the prism, greatly facilitating the drainage of the whole upper part of the canal as well as Sandusky Pit itself.

During the latter part of the month of May one of the pumps from the lower coffer-dam was set up in the Ballinger Rock pit, which it soon pumped dry, and the contractors, upon the completion of the work at the guard-lock, were able to place their force at work at Ballinger's without any delay.

To facilitate these operations, a force of Government laborers were kept constantly at work bailing, digging drains, stopping leaks, repairing cross-banks, and all the little et ceteras necessary to enable the contractors to excavate the pits.

Some of the material taken from excavations at the upper canal entrance was placed so as to form a dike reaching from the guard-lock to a point about 600 feet above, and so placed as to turn the water from the Nashville Creek and prevent its forming a bar at the entrance to the guard-lock, and some of the rock from the upper end of the pit was placed so as to form a guide-pier on the outside line of the channel excavation.

Excavating for foundation for guard-lock was commenced in October, 1873, and extended to June 6, 1874, when the excavation included in this section was completed and the riprap wall laid on the dike above the lock to station 30, so far as the rock excavated would build it.

Work was suspended at this point while the contractors were engaged at the lower lock entrance from February 11 to March 17.

The foundation to this lock is similar to that of the middle lock, and required an excavation of from 8 to 15 inches below lock-bottom to get to a stratum of rock suitable for the foundation of the walls. In order to properly dispose of the excavation from the prism of the lock, and make it complete the embankment to the height of the lock-walls, it was necessary to pile the dimension and other stone already delivered for constructing the lock-walls, and which lay scattered over the ground adjoining the lock.

This was done with labor employed by the United States. The stone was all piled near the track of the Chicago, Burlington, and Quincy Railroad. The embankment is essentially completed, leaving, however, a sufficient space to put in the lock-walls.

Authority was received to build the circular wall connecting the upper outside wing-wall of the guard-lock with the riprap wall on the canal-bank. The necessary labor was employed, and the wall built above ordinary low water, so that it can be completed without the necessity of building a coffer-dam; this wall came within the coffer-dam built for channel excavation.

There was also built at the same time a circular vertical wall connecting the south abutment of the railroad bridge over the Nashville Creek with the slope-wall inside of the dike for turning the creek.

The guard-lock site is now in good condition to commence work on under the new appropriation, and the lock can be completed in about one year.

On April 8, 1874, Messrs. Kittle & Co. asked for an extension of the time for completing their contract, till October 31, 1874. This extension was recommended on account of the interference with their work in the delay in commencing; outside interference with their men, causing strikes; bad weather, and the flooding of the coffer-dam; and the extension was granted.

The building of the coffer-dams and bailing them by hired labor without the intervention of contractors resulted in a great saving to the Government. The exact figures cannot as yet be given on account of the unfinished condition of the work at the lower dam. The same policy was equally beneficial in the building of the sluices, as the figures on the middle-lock sluices, as given herewith, will show.

The stone for the sluices purchased in open market was delivered face and backing for \$7 per yard, which I believe is the lowest price ever paid on this work for stone of the same quality.

In preparing the statements of construction by hired labor, great care has been taken to ascertain the exact cost of each branch of the work, to furnish information for guidance in future operations, and from the information thus obtained, I am justified in saying that it is by far the best plan for the United States to do this class of work by their own employes. It has cost much less than any contract work on this improvement. The employés of the United States have no other interest than to carry out to the full extent all the instructions received, and to do the work in the very best manner,

and a majority of the funds appropriated go directly to the laborers employed, benefiting the many, and not, as under the contract system, a large percentage profiting the few.

Fifteen cents per square foot on the sluice-wall and five cents per square foot on the vertical wall would have bush-hammered the face of the walls, and then they would have been of the same class of work as the cut-stone masonry, for which the lowest price paid the contractors was \$8 per yard.

Result of operations on the "guard-lock," section work, and channel excavations under contract of Messrs. J. W. Kittle & Co., for the fiscal year ending June 30, 1874.

Quantities.	Items.	Contract price.	Amount.
<i>At guard-lock.</i>			
35,482	Cubic yards earth excavation	\$0 50	\$17,741 00
13,451	Cubic yards rock excavation	2 20	40,658 20
265	Cubic yards, laying face of riprap wall	1 00	265 00
<i>Section work and channel excavations.</i>			
74,269.9	Cubic yards earth excavation	50	37,134 95
26,062.1	Cubic yards rock excavation	2 20	57,336 62
1,930.3	Cubic yards, laying face of riprap wall	1 00	1,930 30
	Total		155,066 07

Results of operations on the middle lock, under contract of Willard Johnson, for the fiscal year ending June 30, 1874.

Items.	Quantities.	Contract price.	Relative price.	Amount.
Earth-excavation	4,895.00 cubic yards.	\$0 40		\$1,958 00
Rock-excavation	1,704.23 cubic yards.	2 00		3,408 46
Constructing slope-wall	514.00 cubic yards.	1 00		514 00
Constructing cut-stone masonry, (stone-dressing) ..	241.00 cubic yards.	8 00	\$5 00	1,905 00
Cut-stone masonry, (competing)	452.67 cubic yards.	8 00	3 00	1,358 01
Handling and putting into work wrought iron ...	1,439.00 pounds.	10		143 90
Total				8,587 37
Deduct :				
Cut-stone masonry overestimated in previous estimate.	231.17 cubic yards.	8 00		1,849 36
Balance				6,735 01

Results of operations on the lower lock, under contract of Messrs. Dull and Williams, for the fiscal year ending June 30, 1874.

Bailing and draining	\$1,000 00
102,075 cubic yards cut-stone masonry, \$10	1,020 75
137.57 cubic yards constructing slope-wall, \$1.50	206 35
190.25 cubic yards loose stone, \$1	190 25
Total	2,417 35

Exhibit of stone delivered at the lower and middle locks, under contract of Messrs. Wells, Timberman & Co., for the fiscal year ending June 30, 1874.

Items.	Quantities.	Contract price.	Amount.
LOWER LOCK.			
Face-stone.....	85.97 cubic yards.	\$16 00	\$1,535 32
Slope-wall stone.....	814.61 cubic yards.	5 00	4,073 05
Total.....			5,608 37
MIDDLE LOCK.			
Face-stone.....	186.84 cubic yards.	\$15 50	2,896 02
Slope-wall stone.....	799.13 cubic yards.	5 00	3,995 65
Total.....			6,891 67
<i>Labor hired by the United States.</i>			
MIDDLE LOCK.			
Slope-wall, average cost.....	1,550.35 cubic yards.	\$1 43	2,221 40
Macadam, average cost.....	603.05 cubic yards.	1 27	765 62
Grading and filling back of walls.....			153 19
Total.....			3,139 21
LOWER LOCK.			
Slope-wall, average cost.....	183.00 cubic yards.	\$1 50	275 30
Hauling broken stone.....			134 75
Rebuilding slope-wall.....			64 00
Pointing 1,055 square feet vertical wall.....		25	263 75
Total.....			737 80

Constructing sluice at middle lock.

9,680 cubic yards earth-excitation.

103 cubic yards rock-excitation.

3,704 cubic yards sluice and vertical wall laid.

This quality of masonry includes the vertical wall, connecting sluice-wall with upper and lower inside lock-walls.

The average cost of earth-excitation is, per cubic yard..... \$0 35

The average cost of rock-excitation is, per cubic yard..... 1 50

The average cost of sluice and vertical wall, per cubic yard..... 3 53

Constructing sluice at lower lock.

About 12,500 cubic yards earth-excitation.

50 cubic yards rock-excitation.

1,154.16 cubic yards stone, dressed.

653 cubic yards stone, laid.

Guard-lock.

Items.	Quantities.	Rate.	Amount.
Stone piled.....	2,392. cubic yards..	\$0 67 1/2	\$1,616 30
Masonry laid in cement in Nashville Creek wall.....	330. cubic yards..	2 29	953 70
Excavation for same.....	280. cubic yards..	50	1,400 00
Cut-stone masonry in bank-head.....	686.5 cubic yards..	5 37	3,681 70
Concrete in same.....	200. cubic yards..	1 00	200 00
Bailing and draining during the construction of the bank-head.....			367 20
Total.....			6,825 90

Exhibit of stone purchased in "open market" of Messrs. Wells, Timberman & Co.

For middle-lock sluice and finishing slope-wall :

1,623.35 cubic yards rubble-stone, \$7.....	\$11,363 45
206.85 cubic yards dimension-stone, \$12.....	2,482 20
241.69 cubic yards slope-wall stone, \$5.....	1,208 45
Total.....	15,054 10

The lower-lock sluice :

2,905.84 cubic yards rubble-stone, \$7.....	\$20,340 88
---	-------------

Exhibit of cement purchased in "open market" of Mr. James Clark.

For middle-lock sluice :

2,100 barrels, (300 pounds each,) \$2.48.....	\$5,208 00
---	------------

For lower-lock sluice :

230 barrels, (300 pounds each,) \$2.48.....	694 40
---	--------

The amount of funds available for this work at the beginning of the fiscal year was—

Balance from last year's appropriation.....	\$66,300 88
Appropriated by act approved March 3, 1873.....	400,000 00

There has been expended.....	466,300 88
	344,987 18

Remaining at the end of the year.....	121,313 70
Amount appropriated by act of Congress approved June 23, 1874.....	400,000 00

Amount available for fiscal year ending June 30, 1875.....	521,313 70
--	------------

Amount required beyond appropriation for completing the work, about. 480,000 00

The sum of \$480,000 could be advantageously used during the fiscal year ending June 30, 1876, and I would earnestly recommend that an appropriation of that amount be made as soon as possible to finish the work.

During the present year it is proposed to finish the work embraced in the contract of Kittle & Co., finish the sluices, prolong the bridges over the creeks which empty into canal, build the riprap wall as far as material can be found for it, and build the entire guard-lock, if possible.

In conclusion, I have to bear witness to the faithful manner in which the gentlemen connected with the engineer force have performed the various duties assigned them.

Very respectfully, your most obedient servant,

AMOS STICKNEY,

Captain of Engineers and Brevet Major, U. S. A.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

Abstract of proposals received at United States Engineers' office, Keokuk, Iowa, July 21, 1873, for labor required on guard-lock, section work, and channel excavations.

Number.	Name.	Residence.	Names of guarantors.	Residence.	1 to 4 miles, more or less.		60,500 cubic yards, more or less.		60,500 cubic yards, more or less.		2,000 cubic yards, more or less.		20,500 cubic yards, more or less.		20,500 cubic yards, more or less.		200 cubic yards, more or less.	
					Balling and draining.		Earth-excavation.		Book-excavation.		Labor of puddling.		Laying face of riprap wall.		Concrete masonry.		Aggregate.	
					Rate.	Am't.	Rate.	Am't.	Rate.	Am't.	Rate.	Am't.	Rate.	Am't.	Rate.	Am't.	Rate.	Am't.
1	J. K. Hornish, } John Alair Mc- } Dowell.	Keokuk, Iowa, } Lee County.	J. P. Hornish } S. Hamill & Co. }	Keokuk, Iowa } do do do do }	\$3,650	\$3,650	\$0 60	\$41,100	\$2 50	\$151,250	\$0 50	\$1,000	\$1 10	\$22,550	\$5 00	\$1,000	\$220,550	
2	Guy Wells.....	do do do do	Wm. Timborman } Samuel E. Carey }	do do do do }	4,000	4,000	60	41,100	3 50	311,750	1 00	2,000	2 00	41,000	7 00	1,400	301,250	
3	L. L. Hine.....	do do do do	W. H. Meddel } B. H. Smith } H. N. Bestwick }	do do do do }	625	625	48	32,880	1 99	120,385	50	1,000	1 00	20,500	4 00	800	176,900	
4	Samuel G. Bridgman.....	do do do do	J. N. Amourant } A. J. Hine } R. H. Wynan }	do do do do }	1,000	1,000	30	20,550	2 75	166,375	90	400	1 00	20,500	1 00	200	209,025	
5	J. W. Kittle & Co*.....	do do do do	A. L. Connable } F. L. Warner } William Patrick }	do do do do }	800	800	50	34,250	2 90	133,100	50	1,000	1 00	20,500	4 00	800	190,450	
6	George Williams.....	do do do do	do do do do	do do do do	1,000	1,000	60	41,100	3 50	311,750	1 00	2,000	2 00	41,000	5 00	1,000	297,850	
7	Willard Johnson.....	Fulton, N. Y., } Oswego County.	George M. Chase.....	Fulton, N. Y. } do do do do }	5,000	5,000	55	37,675	3 50	311,750	50	1,000	2 25	46,125	5 00	1,000	302,550	

* The lowest responsible bidder.

I 3.

IMPROVING ROCK ISLAND RAPIDS, MISSISSIPPI RIVER.

The work of excavation at Rock Island Rapids, done in the fiscal year 1872-1873, under contract with Dull and Williams, was finished before the 1st July, 1873, but the closing of the contract by a final estimate had to be deferred to September 15, 1873, as the high water prevented a thorough resurvey of the places at Winnebago chain and some patches between St. Louis chain and Campbell's chain. At Winnebago chain, 2,144 cubic yards, and at the latter places, 220 cubic yards of rock had been removed. For the fiscal year ending June 30, 1874, an appropriation of \$50,000 was made. At the letting of the work on 5th June, 1873, Mr. Geo. Williams was the only responsible bidder, and I was authorized to enter into contract with him; and by his energy and skill the work of excavation, by means of chisel and dredge, has been pushed with each success that by 24th October, 1873, I settled his final estimate under that contract, which embraced in all 1,801 cubic yards of rock-excavation.

There remain to be excavated 7,199 cubic yards to complete the improvement of Rock Island Rapids under the approved scheme. I expect to excavate about 3,300 cubic yards at lower chain, and at scattering patches during the fiscal year ending June 30, 1870, by means of the \$50,000 appropriated on 23d June, 1874. There would then remain about 4,000 cubic yards of rock to be removed, chiefly at foot of Moline chain, and at scattering patches, and as this remaining work can only be done by means of chisel and dredge, under all the difficulties of a very strong river-current and the liability of frequent interruptions from passing rafts and steamers, the price of \$16 a cubic yard is not estimating the cost too high; and I, therefore, most earnestly recommend that the sum of \$80,000 may be appropriated for completing the improvement.

For any information more in detail in regard to this work, I beg leave to refer to the report of Assistant E. F. Hoffman, who has so ably conducted the operations from the beginning.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$50,000 00
Amount in hands of officer, and subject to his check, (including \$2,999 per centage due on contracts not yet completed).....	4,034 74
Amount appropriated by act approved June 23, 1874	50,000 00
Amount expended during the fiscal year ending June 30, 1874.....	51,694 04
Amount available July 1, 1874	52,340 70
Amount required for the fiscal year ending June 30, 1876	80,000 00

Report of Mr. E. F. Hoffman, Assistant Engineer.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July 1, 1874.

COLONEL: I have the honor to submit my annual report of operations for the improvement of the Rock Island Rapids, during the fiscal year ending June 30, 1874.

The work of excavation done under the contract by Messrs. Dull & Williams, for the fiscal year 1872 to 1873, which could not be closed by a final estimate before July 1, 1873, on account of the high stage of water, making a thorough hydrographic survey and revision inconvenient, was finally reported to you as being executed satisfactorily in conformity with the contract, whereupon the relations with the firm of Messrs. Dull & Williams on the part of the Government were declared to be ended, and the following final estimate was drawn up on September 15, 1873, and duly signed by both parties.

Final estimate of work done by Dull & Williams, under their contract for the improvement of the Rock Island Rapids of the Mississippi River, commencing September 28, 1872, and ending September 15, 1873.

TOTAL AMOUNT OF WORK DONE.

Items.	Contract price.	Relative price.	Amount.	Percentage retained.	Amount of payment.
2,144 cubic yards rock-excavation and removing at Winnebago Island	\$12 50	.....	\$26,800		
220 cubic yards rock-excavation and removing at patches, between Saint Louis and Campbell's chain	14 50	.....	3,190		
			29,990	\$2,999	\$26,991
Total amount of work done, including retained percentage					29,990
Deduct from payments, as per receipted vouchers					26,991
Balance due					2,999

J. N. MACOMB,
Colonel of Engineers, U. S. A.
DULL & WILLIAMS.

For the work of excavation at these rapids, Congress had appropriated the sum of \$50,000 for the fiscal year 1873-1874.

Previous to the letting of the work, the subject was considered by the Chief of Engineers if the work of excavation by means of chisel and dredge could not be carried on more advantageously at the remaining scattered patches by the Government.

You were directed to report upon this subject, and, after mature consideration, the fact appeared in figures that, as the purchase of the necessary implements was out of question on account of the small appropriation, the excavation per cubic yard, even by hiring machinery, would reach the price of \$16.50. If, at the commencement of the improvement of these rapids, the requisite machinery in chisel, dredge, steamer, flat and dump boats could have been built or bought by the Government, I am confident a great saving of money would have been the result, and the quality of work superior. At the present advanced state of the work, even if the means for purchase of machinery were at hand, no pecuniary advantage would be gained.

Excavation by means of chisel and dredge is a difficult kind of work and a precarious one, if the engineering and superintending are not carried on with all zeal and fidelity. It should but be used when coffer-damming is utterly impossible on account of scattered patches.

In relation to work of excavation done by means of coffer-damming on the part of contractors and on the part of Government, I can exhibit an interesting comparison obtained at this place.

The work of coffer-damming and excavating at these rapids has been done by contract. The within table exhibits place, amount of rock-excavation, running feet of coffer-dam, and ratio between excavation and running feet of coffer-dam.

Coffer-dam work at the Rock Island Rapids.

Denomination.	Running feet of coffer-dam.	Amount of cubic yards.	Ratio between amount of cubic yards and am't of running feet of coffer-dam.	Contract price per cubic yard.	Amount paid.
Duck Creek	1,420	5,183.80	3.65+	\$10.00	\$51,838 00
Moline, above grade	2,530	16,069.00	6.7+	10.00	160,690 00
Moline, below grade		889.40		5.56	4,945 11
Big Sycamore, at above grade	4,385	12,270.00	3.6+	13.00	159,521 70
Big Sycamore, below grade		3,533.25		8.79	31,057 98
Little Sycamore	1,350	1,953.11	1.4+	13.00	25,390 43
Campbell's	3,320	8,801.20	2.6	11.50	101,215 40
Smith's	2,181	5,598.87	2.5	10.35	57,948 30
Head of Sycamore	1,715	1,622.30	.94	11.00	17,445 30
Upper chain	1,815	3,697.50	2.03	14.00	51,765 00
Crab Island	2,080	2,525.30	1.29	11.50	29,629 45
Total		62,142.72			691,246 03

NOTE.—Average cost-price per cubic yard, \$11.10.

In the year of 1872 it became necessary to excavate the eastern channel of the draw-pier of the new Government bridge at this place, situated at the foot of the rapids. This work was done by the Government under the head of Rock Island bridge appropriation.

The within table contains the cost per cubic yard of excavated rock at that place and the ratio between amount of cubic yards and amount of running feet of coffer-dam. The information was obtained from the maps and records in the office.

Rock-excavation in the pit of the coffer-dam erected in the eastern channel of the draw of Rock Island Government bridge.

Denomination.	Running feet of coffer-dam.	Amount of cubic yards.	Ratio between amount of cubic yards and amount of running feet of coffer-dam.	Price.	Amount paid.
Eastern channel	1, 140	3, 062	2 7	\$10 00	\$30, 620

In comparing the results in both exhibits it will be seen that the average cost-price per cubic yard obtained by contract-work is not much higher than the price for which Government did the work of coffer-damming and excavating. If, furthermore, it is taken into consideration that the erection of coffer-dams, such as are at Sycamore, Moline, and Smith's chain, was done in a current of the river running with a velocity from 6 to 8 feet per second—meanwhile the Government coffer-dam at the bridge was set in nearly calm water—the comparison in regard to cheapness stands for this instant in favor of contract-work. Even the ratio between amount of cubic yards excavated to the amount of running feet of coffer-dam is in advantage of contract-work, as can be readily seen from the above exhibits.

In laying the above before you I state that I confine myself for making this comparison only for this locality under the mentioned circumstances, having no doubt that other results in favor of Government work can be and are obtained.

In consequence of your report to the Chief of Engineers, showing the price for excavating a cubic yard of rock by means of hired implements to be \$16.50, you were authorized to advertise the work, and on the 5th of June, 1873, bids in relation to the work were opened. Mr. George Williams, of Keokuk, Iowa, was the only bidder, and you were empowered to enter into contract with him for the work of excavation at Duck Creek chain, at the price of \$18 per cubic yard; lower chain, at the price of \$16 per cubic yard; foot of Moline chain, at the price of \$12 per cubic yard: various places on the rapids, at the price of \$14 per cubic yard.

The contractor, Mr. George Williams, was notified to commence work, and Mr. C. H. Benck and Mr. John F. Wallace, civil-engineer assistants, were intrusted with the superintending in the field. They lived on a small quarter-boat with their parties during the season, right at the place of the work, and, as ever, performed the duties assigned to them with ability and faithfulness.

I submit here an extract from their joint report in reference to the work of excavation during the fiscal year 1873-1874:

The excavation during the past season was carried on under a contract with Mr. George Williams, of Keokuk, Iowa, who used four chisel-boats and two dredges in the prosecution of the work, and excavated 800 cubic yards of rock at the head of Duck Creek chain, 680 cubic yards at lower chain, 296 cubic yards at foot of Campbell's chain and a crib containing 25 cubic yards below lower chain.

Owing to the high stage of water the commencement of the work was delayed until about the 15th of July, 1873, at which time work was commenced with two chisel-boats at the head of Duck Creek chain. On the 23d of July the two other boats commenced operations at lower chain, and the work was carried forward on the part of the contractors with great diligence until its completion.

On the 28th of August, one chisel-boat, having finished its work at Duck Creek chain, was transferred to the foot of Campbell's chain.

The following table will show the number of days that the chisel and dredge boats worked at each locality. From which we find that—

The dredge removed on an average at Duck Creek chain 26 cubic yards per day.

Lower chain, 212 cubic yards per day.

Foot of Campbell's chain, 26 cubic yards per day.
 Crib below lower chain, 25 cubic yards per day.
 And that a chisel-boat cut on an average—at
 Duck Creek chain, 10 cubic yards per day.
 Lower chain, 5.5 cubic yards per day.
 Foot of Campbell's chain, 11.4 cubic yards per day.

Designation.	Number of days worked.	
	By dredge.	By chisel.
Duck Creek chain.....	31	81
Lower chain.....	32	125
Foot of Campbell's chain.....	12	26
Crib below lower chain.....	1	.....

The work of inspection was greatly assisted and simplified by the use of the steam and self-registering sounding machine "Col. J. N. Macomb." On the following dates the work was inspected and recommended by you for acceptance:

Duck Creek chain, September 27, 1873.
 Lower chain, October 16, 1873.
 Foot of Campbell's chain, October 7, 1873.
 Crib below lower chain, September 27, 1873.

Our duties consisted in finding the patches of rock and marking them with buoys, and in directing the boats where to work; also in giving the workmen grade, to which they had to work from the surface of the water, which we found each day by observation and calculations from our bench-marks at each chain where our work was carried on; and also in observing, calculating, and plotting upon our field-maps the position of the boats at least twice each day; and in case the boats moved to a new patch, more observing, calculating, and plotting was rendered necessary. Quite frequently the boats were torn out of their positions by rafts and steamers, and caused us a great amount of work and annoyance in replacing them.

It was also necessary at each chain to keep the line of excavation marked by buoys, which were almost daily removed and had to be as often replaced. As soon as a dredge commenced dredging the loose rock, we had to watch that the material was deposited at the places ordered by you. These duties kept us and our men constantly employed, and when we consider that these duties required our presence at three different chains, which were several miles apart, each day, you will see that our time was fully taken up in the discharge of our various duties. On account of the low stage of water during the later part of the season and the situation of the work, especially on lower chain, where the work lay in the middle of the channel, the boats were subject to a great many accidents, caused by steamboats and rafts coming in contact with them, which resulted in breaking of spuds, loss of rope and anchors, and in general damage of the boats, and also in loss of time taken up in the replacing of the boats to their former positions, which, when we consider the velocity of the current, which was from 5 to 6 miles an hour, was a difficult undertaking.

Some accidents also occurred by the breaking of chains and machinery on the boats, but accidents from this cause occurred less frequently than in former years, owing to the improving of the tools and machinery by the contractors. Especially we would bring to your notice the improved chisel-point introduced by Mr. Whitney, which, in case of its being dulled or broken, can be replaced in an hour, whereas formerly chisel-boats were often delayed for days together from these causes. We would also bring to your knowledge the fact that the field-maps furnished us by you were a great assistance to us in the successful prosecution of the work.

The work of excavation having been executed in conformity with contract, a final estimate was made under date October 20, 1873, which closed the contract between the Government and Mr. George Williams for the appropriation available during the fiscal year 1873 and 1874, and is within.

Final estimate of work done by George Williams, under his contract for the improvement of the Rock Island Rapids of the Mississippi River, commencing June 11, 1873, and ending October 20, 1873.

TOTAL AMOUNT OF WORK DONE.

Items.	Quantities.	Contract price.	Amount.	Percentage retained.	Amount of payments.
Rock-excavation and removing at Duck Creek chain	800 cubic yards..	\$18 00	\$14, 400 00		
Rock-excavation and removing at lower chain	680 cubic yards..	16 00	10, 880 00		
Rock-excavation and removing at various places on the Rock Island Rapids near Campbell's chain	296 cubic yards..	14 00	4, 144 00		
Rock-excavation and removing at various places on the Rock Island Rapids between lower chain and foot of rapids	25 cubic yards..	14 00	350 00		
			29, 774 00	\$2, 977 40	\$26, 796 60

Total amount of work done, including retained percentage..... \$29, 774 00
Deduct former payments as per receipted vouchers..... 26, 796 60

Balance due..... 2, 977 40

J. N. MACOMB,
Colonel of Engineers, U. S. A.

GEORGE WILLIAMS.

Congress appropriated \$50,000 for the fiscal year 1874-1875, to continue the work of improvement. You were notified of this fact, and directed me to submit a report in relation to a project according to which the work of excavation might be carried on, during the fiscal year 1874-1875, with the available appropriation of \$50,000. In obedience to the above I stated the within.

The yearly report of last year showed that 9,000 cubic yards of rock were to be removed during the fiscal year 1873-1874. Of this amount but 1,801 cubic yards could be worked out during the last year, owing to the fact that the price for a cubic yard of rock to be removed was, at the different chains, very high. There remain 7,199 cubic yards of rock to be removed for completing the improvements of these rapids at the following localities:

1st. At lower chain, about..... 3, 000 cubic yards of rock.
2d. At Moline chain, (foot,) about..... 3, 400 cubic yards of rock.
3d. At various places, about..... 799 cubic yards of rock.

Total, about..... 7, 199 cubic yards of rock.

Under your always-expressed view of continuing the improving of these rapids in such manner that those places should be worked first which would give the navigation the most benefit and which could be removed fully in one season, without making the completion dependent upon another appropriation, I would state that, first, by erecting a coffer-dam at lower chain, 3,000 cubic yards of rock could be taken out with great advantage to navigation. I have to mention that you changed the previous entertained project of improving this chain. The idea was to straighten the present deep channel, which lays in the shape of an elbow, by making a direct cut through its base. Experience shows that in such shortenings the current of the water follows always the old natural channel. The reason is to be found in the difference of the depth of water, which in the natural channel varies from 8 to 20 feet, and more; meanwhile the excavated cut has only a depth of 4 feet below low water of 1864. It happens, therefore, especially in a lower stage of water, that when at such places the long Mississippi steamers enter the cut with their bows, the stern frequently drifts quicker with the current in the natural channel and throws the steamer on the edges of the cut. After you heard pilots express their preference to use the natural channel, instead to run through a cut, you decided rather to improve the natural by widening it. The high cost of a cut, and the doubtful benefit for navigation gained by it, were strong motives in the alteration of your first project.

Under No. 3, 799 cubic yards of rock are mentioned, under the signification "at various places at these rapids," which should be removed in such quantities as the engineer in charge might direct. It is not possible to specify the different small patches and boulders which are contemplated to be removed, as this kind of work is dependent from the main work of excavation at lower chain, and the price per cubic yard to be obtained in a future letting. The more No. 1, lower chain, requires, the less can be done under No. 3 at various places, and *vice versa*. Of No. 2, improving Moline chain, (foot,) it can but be recommended to be completed under a future appropriation.

Your project for continuing the work for the fiscal year 1874-1875 is at present under consideration of the Chief of Engineers, United States Army. In reference to the subject of closing the improvements of the Rock Island Rapids of the Mississippi, I am confident that another appropriation for the fiscal year 1875-1876 will enable you to finish this great work, of which but one opinion is prevailing, *i. e.*, that in its permanency proves to be a thorough help to navigation.

At the present date, July 1, 1874, there remain to be excavated 7,199 cubic yards of rock at these rapids. Of this amount, from 3,000 to 4,000 cubic yards it is expected to be disposed of by the appropriation of \$50,000 for the fiscal year 1874 to 1875, the exact amount being dependent upon the higher or lower prices to be obtained at the next letting of the work. According to the experience made at previous lettings, the average price per cubic yard in coffer-dam work, at similar chains, assumed to be \$10, and that of chisel and dredge work to be assumed to be \$12, would allow to excavate—

At lower chain, 3,000 cubic yards, at \$10.....	\$30,000
At various places, 333 cubic yards, at \$12.....	4,000
For superintending, surveying, and contingencies	16,000
	50,000

From this exhibit it will be seen that about 3,330 cubic yards are likely to be removed this year. This amount deducted from 7,199 cubic yards leaves 3,869 cubic yards, or round 4,000 cubic yards, dependent upon the appropriation for the fiscal year 1875-1876. As all this amount of rock can only be excavated by chisels and dredge at places of the rapids where the velocity of the current is from 8 to 9 feet per second, the cost per cubic yard might be assumed with certainty to be \$16. The amount of money, therefore, adding to it the cost for engineering, superintending, contingencies, with \$16,000 for this last year, would be \$80,000.

4,000 cubic yards, at \$16.....	\$64,000
Superintending, &c., &c.....	16,000
Total	80,000

With the requested appropriation of \$80,000 for the year 1875-1876 the work of improving the Rock Island Rapids would be ended.

In your last annual statement to the Chief of Engineers you applied for the sum of \$112,000 for the purpose of finishing the rapids. Of this sum but \$50,000 have been appropriated by Congress, which would leave a sum still to be required of \$62,000 for the completion of the work, according to your last annual report. At this year the required sum for finishing the improvements is, as above stated, \$80,000.

The apparent inconsistency of asking \$80,000 for the completion of the Rock Island Rapids improvement, instead of \$62,000 as the balance, is explained thus:

1st. By the higher average price of excavating a cubic yard of rock at the singular-shaped scattered patches, the position of which, being like an island in the channel, demand frequent shifting of chisel-boats for allowing steamers and rafts to pass, and thereby not only creating loss of time, but exposing the boats to breakage or injuries by collision, a defense with cribs being out of the question in the channel of the river.

2d. By the contingencies which are necessarily continued a year longer, of which the part of engineering demands more superintendence, consequently a greater cost at these patches than in the pit of large coffer-dams.

In the office assistants and draughtsmen have been engaged in calculating and plotting additional hydrographic surveys for the completion of the Rock Island Rapids maps.

Also, here I take pleasure to bring to your notice the faithful services rendered by the already-mentioned civil engineer assistants and the draughtsman, Mr. A. Stibolt.

All of which is respectfully submitted.

E. F. HOFFMAN,
Civil Engineer.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

I 4.

IMPROVING ILLINOIS RIVER.

At the urgent request of the Governor of Illinois, and of many others interested in forwarding the work of improving the Illinois River on the basis of a slack-water navigation, I recommended that some four-fifths of the last appropriation of \$100,000 (granted by act approved March 3, 1873) should be applied toward putting in the foundation for the lock near Copperas Creek. This recommendation was adopted by the War Department, and left a small margin for continuing the work of dredging and removing snags at the localities where such work was most needed for immediate relief to the navigation.

The work at the lock-pit was begun under a contract with Willard Johnson on 1st September, 1873, and continued until about the middle of December, when it was interrupted by a flood in the Illinois River which rendered it necessary to let the water into the lock-pit to relieve pressure and prevent disaster. Under these circumstances, I felt myself under the necessity of approving the suspension of work until favorable conditions should recur. On the 10th of April, 1874, the contractor floated a dredging-machine into the lock-pit and resumed the operation of excavating the earth, and continued until the 19th of May to work by that mode with advantage.

The contractor has not pushed this work to the best of his ability, and his tardiness has been frequently called to his notice, and has only been tolerated from the fact that he has the contract with the State for the lock-masonry, and will consequently have only himself to blame if the foundation or bottom is not in readiness when his time may come for beginning the superstructure.

The work of dredging and removing of snags was resumed at Beardstown Bar on 15th September, 1873, and prosecuted there, and at various other points where the best results could be obtained, with the limited means at our disposal. The report of Mr. R. A. Brown, assistant in local charge, gives a full exhibit of this work, as well as that at the lock-pit near Copperas Creek; and I beg leave to refer to it for more detailed information.

The accompanying financial statement shows an amount available on 1st July, 1874, of \$118,104.44, including the new appropriation of \$75,000.

This last will be applied, as set forth in the report of the assistant engineer in charge, to payments under new contract for dredging and building dams at such points as may be deemed most advantageous for the work under the approved plan for prosecuting it.

The remaining \$43,104.44 is pledged for work in progress, and would have been disbursed ere this, save for the interruptions to the work already alluded to.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$95,000 00
Amount in hands of officer and subject to his check.....	3,719 19
Amount appropriated by act approved June 23, 1874.....	75,000 00
Amount expended during the fiscal year ending June 30, 1874.....	52,796 75
Amount available July 1, 1874.....	118,104 44
Amount required for the fiscal year ending June 30, 1876.....	150,000 00

*Report of Mr. R. A. Brown, Assistant Engineer.*UNITED STATES QUARTER-BOAT AT THE SITE OF COPPERAS CREEK LOCK,
Fulton County, Illinois, July 20, 1874.

COLONEL: I have the honor to submit the following report of operations for the improvement of the Illinois River during the fiscal year ending June 30, 1874:

Advertisements were issued from your office dated June 30, 1873, calling for "Proposals for the prosecution of the work of constructing a foundation for a lock at Copperas Creek," up to August 12, 1873.

Bids were opened on the 12th of August and contract awarded to Mr. Willard Johnson, of Fulton, Oswego County, New York, (he being the lowest bidder;) which contract was finally executed August 30, 1873.

The contractor, with a small force, commenced grubbing and clearing September 1. The 9th of September Mr. Joseph Utley, president of the board of canal commissioners, and Mr. D. C. Jenne, engineer for the State of Illinois, were present, and made a final location of the site of the lock.

The work for earth-excavation was laid out on the 10th and excavating commenced on the 11th, at which good progress was made during September and up to about the 15th of October, since which time a want of experience has been shown on the part of the superintendent for contractor in dealing with work of this character. In justice to him, however, I will state that the elements have not been altogether favorable, and the work itself is of a difficult nature.

Operations continued to progress slowly up to the 10th of December, when a severe rain-storm caused a suspension.

Most the east half of the pit was excavated to grade nine (9) feet below low-water surface, and on the 9th the first bearing pile was driven. Nine piles were driven, when the rise of the river so threatened the works that it was deemed expedient to remove the machinery. After this the whole force was engaged re-inforcing the embankment constructed for a coffer-dam, and so continued during the 11th, 12th, 13th, 14th. and 15th; in the mean time the foot of slope on the east side of pit, not being properly secured, commenced to slide.

The river had now reached a stage of 9½ feet above low water, being 18½ feet above the bottom of the pit. This great pressure caused the water to ooze through the porous material quite freely, accompanied by large land-slides extending more than half way across the pit.

The superintendent, fearing a general breach of the bank, caused the pit to be flooded by cutting a ditch below the southeast angle, entering the pit near the southwest angle.

By the morning of the 16th the pit was completely flooded to within one or two feet of the top of banks, and on a level with the river.

Application was now made by Mr. Bruce, the superintendent, for permission to suspend operations for a season, to resume as soon as the stage of water and state of weather would permit. This I forwarded to you and received your approval on the 24th.

Work was accordingly suspended and the force dismissed, with the exception of one foreman, with a few men and one team, to care for the material, implements, &c.

On the 31st December Mr. Johnson, the contractor, was notified that his personal attention was required at the work; this notice being forwarded to you for your indorsement.

During the months of January, February, and March no progress was made. A small force was present engaged in securing material from the spring flood.

On the 10th of April, the river having fallen to a stage of 7.5 feet above low water, a dredge was put at work in the lock-pit, to complete the excavation, and worked until the 19th of May, when it was withdrawn, and the breach connecting the pit with the river closed. Piling was then driven within the pit, outside of the line of foundation, for the support of the sheet-piling for a coffer-dam, and two pumps set at work to free the pit from water, which was accomplished about the 1st of June. During this month ditching and excavating have progressed slowly with a small force. Two steam pile-drivers have been at work during the latter part of the month, with the results as shown in June estimate.

Mr. Johnson, the contractor, and Mr. Bruce, his superintendent, have been notified verbally that measures must be taken to insure a more vigorous prosecution of the work; within the last ten days a more enterprising spirit has developed, and I have faint hopes that the work will be pushed hereafter with more energy.

On the application of the contractor, dated April 11, favorably indorsed by you April 22, an extension has been granted until November 1, 1874, for the completion of the work under this contract; but I see no reason why, should the season prove favorable, it cannot be accomplished by the 15th of September.

The total amount of work done under this contract for lock foundation, up to and including June 30, 1874, is as per estimate :

Items.	Quantities.	Cost price.	Amount.
Grubbing and clearing		\$3,000 00	\$3,000 00
Earth excavation	47,561 cubic yards.....	35	16,646 35
Bearing-piles furnished.....	51,865 linear feet.....	16	8,298 40
Bearing-piles driven and cut off.....	4,105 linear feet.....	5	205 25
Timber in foundation	660 square feet, board-measure.....	29 00	19 14
Wrought-iron bolts in foundation	73 pounds.....	15	10 95
			28,180 09

Also the delivery of the following material, not estimated :

Items.	Approximate quantities.
Stone for beton	1,547 cubic yards.
Sand for beton	700 cubic yards.
Cement for beton, (Clark's Utica)	330,000 pounds.
Timber.....	333,000 square feet, board-measure.
Plank	85,000 square feet, board-measure.
Bolts and straps	31,930 pounds.
Spikes	13,500 pounds.

Estimate cost of lock-foundation at Copperas Creek, on the Illinois River.

Items.	Quantity.	Contract price.	Amount.
Grubbing and clearing		\$3,000 00	\$3,000 00
Beiling and draining		3,000 00	\$3,000 00
Earth excavation	49,654 cubic yards.....	35	17,378 90
Concrete masonry, (approximate)	1,600 cubic yards.....	5 00	12,800 00
Bearing-piles furnished	57,095 linear feet.....	16	9,135 20
Bearing-piles driven and cut off, (approximate)	45,000 linear feet.....	5	2,250 00
Timber in foundation	487,176 square feet, board-measure.....	29 00	14,128 10
Plank and boards in foundation, (sheet-piling)	10,296 square feet, board-measure.....	33 00	339 77
Plank in foundation, (flooring)	129,650 square feet, board-measure.....	33 00	4,278 45
Wrought-iron bolts and straps	32,294 pounds.....	15	4,844 10
Spikes and nails.....	13,243 pounds.....	10	1,324 30
			72,478 82

For which is pledged \$80,000, after deducting the cost of engineering and contingent expenses.

DREDGING.

Of the \$100,000 appropriation of March 3, 1873, a fund of \$20,000 was allotted to be expended in dredging and snagging at such points on the river as to afford immediate relief to the navigation.

Bids in open market were received for working a dredge and equipment by the hour. A contract was made with Mr. Willard Johnson, of Fulton, Oswego County, New York, (the lowest bidder,) for this work, at the price of \$12 per hour of actual work. Operations were accordingly commenced on the 15th of September at Beardstown Bar, in restoring the channel made in 1871 and 1872.

The improved channel at this bar was in good condition except about 400 feet in the lower section. At this point was an abrupt sand-reef, which rendered the expensive improvement of 1871 and 1872 quite valueless. This I deemed best to remove. In so doing we found an imbedded snag, no doubt causing the collection of sand and consequent obstruction.

This bar being composed of very changeable material may need attention hereafter. The latter part of September, agreeably to your instructions, I made an inspection of the river below Naples to ascertain the most formidable obstruction to navigation. In October surveys were made of School-house, Spar Island, Grand Pass Bridge, Buck-horn, Slim Island, and Sugar Creek Bars, for the purpose of improvement.

The method pursued in this case was, after a careful examination, to lay out the work so as to give the most immediate relief at a minimum cost, at the same time to so locate it that it will form a part of the improvement for a future appropriation.

The bars on the lower river, where the dredge has been operating, are of such a nature that whatever improvement is made will be likely to endure for a long time, as is also the case with most of the bars on this river.

Channels dredged through quicksand-bars will need restoration occasionally. Those formed at the mouths of tributaries are subject to the action of local floods.

As the country becomes more thickly settled, and the bluffs contiguous to the river more generally cleared and cultivated, these tributary streams become more mischievous, and it seems quite impossible, with a reasonable outlay, to restrain their action. The only practicable manner to deal with these cases is to be constantly prepared to restore the destroyed channels whenever the conditions demand it.

The condition of Kickapoo Creek Bar (which has since restored its channel naturally) in 1871 and 1872, Sugar Creek Bar in 1873, and Lick Creek Bar the present season, suggests the question whether it would not be policy or expedient to allot a fund from the regular appropriation, say of \$10,000, in order to grant such aid as will naturally be asked in case of a repetition of the like conditions.

It is claimed that the damage to trade incident to these abnormal deposits on bars is many times the cost of removing the same, and judging from past demands or earnest requests, I am quite confident that a timely and well-directed expenditure at such points would be very highly appreciated, likewise prove a judicious outlay for all parties concerned. It is quite plain that if a dredge had been available, and could have been set in operation at Sugar Creek Bar at the proper time, no delay to low-water navigation would have occurred last season, whereas the suspension of navigation in 1873 at this point, for boats drawing two feet, dates from the 15th of August.

These deposits are also more economically removed when new than when suffered to remain and become compact.

Statement of the amount of work done by the dredge under this appropriation up to June 30, 1874.

Localities.	Time of actual work.	Character and amount of work.		Cost.
		No. of snags removed.	Cubic yards of excavation.	
Beardstown Bar, at \$12	\$1,212 00	A. m.		
Beardstown Bar, at \$9	593 25	101 00		
Grand Pass bridge		65 55	1	\$1,805 35
Moving from Beardstown Bar to School-house Bar		3 00	1	36 00
School-house Bar		27 05		325 00
Spar Island Bar		91 30	2,541	1,096 00
Moving from Spar Island Bar to Buck-horn Bar		92 45	2,220	1,113 00
Buck-horn Bar		4 50		56 00
Moving from Buck-horn Bar to Sugar Creek Bar		172 10	1	2,066 00
Sugar Creek Bar		29 55		359 00
Moving from Sugar Creek Bar to Lick Creek Bar		725 55	*109	8,711 00
Lick Creek Bar		37 30		450 00
		70 00	2	840 00
Total amount of work done to date				16,861 25

* And one raft.

FUTURE PROGRESS.

For the expenditure of the appropriation of June 23, 1874, a scheme has been submitted, viz:

To be applied to the dredging of channels and construction of dams, rip-raps, and jetties, at the following bars, viz:

1. French.
2. Apple Creek.
3. Spar Island.
4. Otwell's.
5. Buck-horn.
6. Little Blue River.

7. Bevington.
8. McKee's Creek.
9. Sugar Creek.
10. Grand Island, (dredging West Point Chute and closing Bath Chute.)

I am not in possession of sufficient data from which to furnish a close estimate of the cost of improving these points.

The object is to make a close examination of all, and select those most needing attention; also to restore such channels as may be destroyed from any cause.

Mr. Robt. E. McMath's report for the fiscal year ending June 30, 1871, gives the total estimate for the improvement of the Illinois River, by the system of dredging and construction of dams in ripraps and jetties, which is as follows, viz: (See Report of Chief of Engineers for the year 1871, at pages 278 and 279.)

1,305,040 cubic yards dredging, at 25 cents per cubic yard.....	\$326,260 00
15,012 cubic yards dams, at \$2.....	30,024 00
Engineering and contingencies.....	35,628 40
	391,912 40

For the prosecution of the work under his estimate was appropriated in the session of 1869 and 1870.....	\$100,000
Allotted from the appropriation of March 3, 1873.....	20,000
Appropriated June 23, 1874.....	75,000

Total.....	195,000 00
------------	------------

Balance to be appropriated.....	196,912 40
---------------------------------	------------

Of which \$150,000 could profitably be expended during the fiscal year ending June 30, 1876, at such points as the present appropriation fails to cover, with the addition of the following bars, viz:

1. Indian Creek.
2. Naples Flats or Gar Island.
3. Florence.
4. Slim Island.
5. Pilot's Peak.
6. Grand Pass.
7. Columbiana.
8. Hurricane Island.
9. Bloom's Landing.
10. Six-mile Island.

Also in the restoring of obstructed channels.

BUSINESS OF THE RIVER.

During the present season efforts are making to establish a regular, reliable, and, as a consequence, a popular fast freight and passenger line of steamers on the river, and, as I understand, so far with marked success.

I have no statistics of the amount of trade done by the St. Louis and Peoria Packet Company. They make semi-weekly trips while a draught of 4 feet of water is insured.

Appended please find a tabular statement, showing the business of the St. Louis and Naples line.

Ice-transportation forms an important if not one of the leading branches of trade of the river. From reliable sources I learn that the mean shipment of ice annually for the past five years is from 90,000 to 100,000 tons, and increasing at the rate of about 25 per cent. per annum. It is the principal source of supply for the whole southern country that is tributary to the Mississippi.

In addition to the ice-transportation, is towed out an average of 250 to 300 canal-boats, loaded principally with grain and lumber. They average about 180 tons each. About one-fourth of these return-boats take loads for Peru, La Salle, Joliet, and Chicago.

Maps are in preparation showing the location of the lock foundation, scale $\frac{1}{100}$; and of the points where the dredge has operated, showing the condition of bars before and after dredging, scale $\frac{1}{100}$; tracings of which I hope to forward to your office soon.

All of which is respectfully submitted.

R. A. BROWN,
Civil Engineers.

Colonel J. N. MACOMB,
Corps of Engineers, U. S. A.

Abstract of bids for the improvement of the Illinois River.—Opened August 12, 1873, at 12 m.

Number of bid.	Bidders' names and residences.	Guarantors' names and residences.	For grub- bing and clearing.	For bailing and drain- ing.	For 43,000 cubic yds. of earth excavation.		For 1,900 cubic yds. of concrete masonry in foundation.		For furnishing and delivering 60,000 lineal ft. of bearing piles.		For driving and cutting off 60,000 lineal ft. of bear- ing piles.	
					Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.
1	James K. Lake, Chicago, Ill.....	M. B. Bailey and W. P. Witherell, Chicago, Ill.	\$4,500 00	\$15,000 00	\$0 25	\$10,750 00	\$5 70	\$10,830 00	\$0 08	\$4,890 00	\$0 12	\$7,200 00
2	Thomas Saulpaugh, Rock Island, Ill.....	E. P. Reynolds and John Crubaugh, Rock Island, Ill.	600 00	10,000 00	40	17,200 00	7 50	14,250 00	15	9,000 00	17	10,200 00
3	Willard Johnson, Fulton, N. Y....	W. S. Nelson and George M. Case, Fulton, N. Y.	3,000 00	3,000 00	35	15,050 00	8 00	15,200 00	16	9,600 00	05	3,000 00
4	D. J. Jenne, Sterling, Ill.....	William Thomas, Ottawa, Ill., and T. J. Robinson, Rock Island, Ill.	500 00	3,000 00	40	17,200 00	8 00	15,200 00	20	12,000 00	08	4,800 00
5	M. Haley & Co., Chicago, Ill.....	Hall, Kimbark & Co. and Sherman, Haley & Co., Chicago, Ill.	1,800 00	5,000 00	60	25,800 00	9 37	17,803 00	15	9,000 00	10	6,000 00
6	M. A. Bryson, Saint Louis, Mo....	J. M. Mason and H. E. Barnes, Saint Louis, Mo.	2,000 00	3,000 00	47	20,210 00	7 00	13,300 00	17	10,200 00	08	4,800 00
Material in foundation.												
Number of bid.	Bidders' names and residences.	For 516,000 feet of timber, (b. m.)		For 142,000 feet of plank, (b. m.)		For 25,000 pounds of wrought-iron bolts and straps.		For 13,000 pounds of spikes and nails.		Total.	Remarks.	
		Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.			
1	James K. Lake, Chicago, Ill.....	\$93 00	\$16,512 00	\$24 00	\$3,408 00	\$0 08	\$2,000 00	\$0 09	\$1,080 00	\$76,080 00	Informal; bid not in duplicate. Do. Lowest responsible bidder.	
2	Thomas Saulpaugh, Rock Island, Ill.....	27 00	13,932 00	25 00	3,550 00	09	2,250 00	08	960 00	81,942 00		
3	William Johnson, Fulton, N. Y.....	20 00	14,964 00	33 00	4,666 00	15	3,750 00	10	1,200 00	73,450 00		
4	D. J. Jenne, Sterling, Ill.....	30 00	15,480 00	25 00	3,550 00	12	3,000 00	10	1,200 00	75,930 00		
5	M. Haley & Co., Chicago, Ill.....	29 50	15,222 00	27 50	3,905 00	13	3,000 00	10	1,200 00	88,730 00		
6	M. A. Bryson, Saint Louis, Mo.....	33 00	17,028 00	26 00	3,692 00	09	2,250 00	09	1,080 00	77,560 00		

COMMERCIAL STATISTICS.

Statement showing the amount of business done by the St. Louis and Naples Packet Line of steamers on the Illinois River.

	1868.	1869.	1870.	1871.	1872.	1873.
Number of trips made	99	130	105	96	93	101

It may be remarked here that we have kept up this trade constantly and regularly since the year 1849, the number of trips made being governed by the length of the season and stage of water; the greatest number of trips being in 1869, when there was a good stage of water the entire season and no failure to make three trips per week occurred.

Statement of amount of freight carried in 1872 and 1873, and articles transported.

Year.	Grain in bulk.	Grain in sacks.	Flour.	Pork.	Lard.	Apples.	Hides.	Meat in bulk.	Cooper- age.	Live stock.	Sun- dries.
	<i>Bushels.</i>	<i>Sacks.</i>	<i>Barrels.</i>	<i>Barrels.</i>	<i>Pkgs.</i>	<i>Barrels.</i>	<i>Pkgs.</i>	<i>Pieces.</i>	<i>Pieces.</i>	<i>Head.</i>	<i>Pkgs.</i>
1872	139, 656	175, 950	16, 400	8, 595	3, 115	20, 000	1, 886	66, 480	3, 377	11, 400	8, 604
1873	198, 330	212, 356	15, 688	4, 846	2, 087	12, 310	4, 254	27, 700	4, 706	10, 545	8, 185

In 1872 was about the first of bulk-grain shipments in this trade, and would have been largely increased in 1873 had the stage of water permitted.

C. L. ROGERS,
President Naples Packet Company.

APPENDIX K.

ANNUAL REPORT OF COLONEL J. H. SIMPSON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1874.

UNITED STATES ENGINEER OFFICE,
St. Louis, Mo., August 1, 1874.

GENERAL: I have the honor to submit herewith my annual report of operations for the fiscal year ending June 30, 1874.

In addition to my duties in connection with the works of improvement under my charge, I have been engaged during the year upon miscellaneous work, as follows:

President of board of engineers convened by special orders No. 169, War Department, Adjutant-General's Office, dated August 20, 1873, to examine the construction of the St. Louis and Illinois bridge across the Mississippi River at St. Louis. Original report submitted September 11, 1873, and supplementary report January 31, 1874.

President of the board of engineers constituted by special orders No. 4, paragraph 1, headquarters Corps of Engineers, Washington, D. C., dated January 6, 1872, which assembled in New York City on the 10th of December, 1873, in accordance with Special Orders No. 160, headquarters Corps of Engineers, dated December 3, 1873, to consider and report upon questions relating to the improvement of the harbor of Mobile, Alabama. Report submitted December 12, 1873.

President of the board of engineers constituted by special orders No. 65, headquarters Corps of Engineers, dated June 1, 1874, to consider and report upon the plans submitted by the St. Clair and Caron.

delet Bridge Company for its proposed bridge across the Mississippi River at St. Louis. The meeting of this board, having been deferred, has been fixed for the 3d of August, 1874.

Very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

K 1.

IMPROVEMENT OF THE MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS.

ALTON HARBOR.

This improvement consisted in the continuation of the construction of the dam between the head of Ellis Island (opposite Alton) and the Missouri shore; the object being the concentration of the water of the river in the main channel on the east side of the island, and thus the erosion of the shoal in front of the city of Alton at its lower portion.

The work at this locality having been fully described in former reports, it is unnecessary in this report to do more than to report the work done during the fiscal year.

No further appropriation having been made for the year, the operations were confined to the expenditure of the balance of \$3,021.82.

The work done was the raising the body of the dam to the height of 8 feet above low water. The work was begun September 20, the materials being purchased in open market, conditional upon delivery in the dam. Favorable progress was made until October 21, when operations were necessarily closed, the means having become exhausted.

The dam was then at the proposed height of 8 feet above low water, except for a distance of about 200 feet, which settled after being brought to height. This settling was local, and must render the body of the dam more compact, if confined to the body of the material; and if due to scour underneath the foundation, the settling can only bring the dam nearer to a condition of stability. As no examination of the work has been made since operations were suspended, no report as to its present condition can be made, except that the break of the water over the dam is continuous, which indicates a good condition. Exact information is not obtainable until the water falls so as to bring the crest of the dam in sight, which will not occur before the latter part of August.

The work done during the fiscal year was the placing—

1,609.04 cubic yards stone, costing.....	\$2,333 11
23 cords brush.....	56 00
Labor.....	421 75
Engineering and contingencies.....	270 96
Total	3,081 82

The original estimate by the board of engineers for the construction of the dam was \$40,000. There was appropriated July 10, 1872, \$25,000, all of which has been expended.

By the terms of the act approved June 23, 1874, appropriating \$200,000 for continuing the improvement of the Mississippi River,

between the mouths of the Ohio and Illinois Rivers, \$15,000 of this amount are to be expended between the mouths of the Missouri and Illinois Rivers, which will doubtless prove amply sufficient for the completion of the dam and its protection at the island. This makes up the full amount of the estimate.

Financial statement.

Amount in hands of officer and subject to his check.....	\$3, 021 82
Amount appropriated by act approved June 23, 1874, to be expended between the Missouri and Illinois Rivers, from the appropriation of \$200,000 for the improvement of the Mississippi River from the Ohio to the Illinois Rivers.....	15, 000 00
Amount expended during the fiscal year ending June 30, 1874.....	3, 021 82
Amount available July 1, 1874.....	15, 000 00

NORTHERN HARBOR OF SAINT LOUIS.

Operations at this locality have been in continuation of the work of the preceding year. The contract awarded to Thomas M. Hackett, for the work at Sawyer Bend, under the appropriation of March 3, 1873, at the opening of bids on the 26th of June, 1873, an abstract of which is contained in the Report of the Chief of Engineers for that fiscal year, page 451, was duly entered into by him on the 16th of July, and closed by payment of retained percentage on January 23, 1874.

Previously-existing contracts under appropriation of June 10, 1872, having expired with the fiscal year, a reletting was authorized May 21, 1873, to cover the unexpended balance of that appropriation, and proposals were opened on the 9th of July, in accordance with an advertisement inviting the same, the contract being awarded to Messrs. Martin Keary & Brothers, the lowest bidders. (See abstract of proposals herewith.) They entered into contract on the 21st of the same month, but after many promises and excuses on their part concerning the commencement of work, I found it necessary, on the 6th of October, to annul their contract in accordance with its terms; and, with the approval of the Chief of Engineers, the work from the 27th of October was carried on under this appropriation, both at Sawyer Bend and Venice dikes, by the purchase of material in open market and the hire of the necessary labor.

Work on Long Diike, at Venice, was delayed so long waiting for the performance of the agreement of Martin Keary & Brothers, that a great part of the working-season was lost, whence the work is still incomplete. The results are: the old dike is raised to 14 feet above low water, and of the extension the foundation is all in; the construction of the dike well advanced, and the upper branch of the T built. It is expected that the extension of the dike will be finished by August 1, 1874, leaving a residue of the appropriation unexpended.

The report of the board of engineers, dated April 13, 1872, included the extension of two dikes between Long Diike and Bischoff's Diike, which may ultimately be necessary; but I judge it best to delay the prosecution of additional works at this locality, since, in the interest of economy, it is well to allow the effects of the raising and extension of Long Diike to develop before extending the others, and if any considerable deposit results in the space between Bischoff's and Long dikes, the intermediate dikes will be much less expensive than now. To extend the dikes as proposed, would now cost \$100,000.

Mr. Hackett commenced work at Sawyer Bend, under his contract, August 21, or as soon as it was practicable to do so on account of the high stage of water prior to that date. The result of the season's operations under his contract, combined with the work done by purchase of material and hired labor, is 2,520 feet of longitudinal dike, which being added to that previously built by the United States and that undertaken by the board of water commissioners of the city of St. Louis, makes 5,445 feet of the two miles recommended by the board of United States engineers in their report of April 13, 1872.

It is now proposed to devote to the continuation of the work at Sawyer Bend whatever balance of the appropriation of 1872 may remain available after the completion of Long Diike at Venice.

The work at Sawyer Bend during the fiscal year ending June 30, 1875, may with advantage be restricted to the continuation of the protection for a distance of 600 feet. That distance, if the curve be continued, will reach a salient point, which would have to be dredged away this year, but if not touched would be removed by the current by another season. I propose to draw from the appropriation of 1874 sufficient to complete this distance if the balance of the appropriation of 1872 is insufficient.

There will remain, besides this 600 feet, a distance of 4,515 feet to be protected, to carry out the recommendation of the board of engineers, which will require \$84,535.52, all of which can be profitably used the coming fiscal year, 1875-1876.

The board of engineers, in their report of April 13, 1872,	
estimated the cost of protection of Sawyer Bend at...	\$142, 211 62
And for the extension of the Venice Dikes.....	197, 323 90

Making a total for the locality now designated as Northern Harbor of St. Louis	339, 535 52
There has been allotted to these works for use up to June 30, 1875	155, 000 00

Balance to be appropriated	184, 535 52
----------------------------------	-------------

This sum is judged to be sufficient to complete the works recommended.

For further details of the work in the northern harbor of St. Louis, I refer to the report of Assistant Engineer D. M. Currie, and accompanying tracings herewith.

HORSETAIL BAR.

The work at this locality, being the first undertaken with a view to the improvement of the navigation as a principal object, a detailed description of the plan and the effects designed is given.

Horsetail Bar has always been one of the worst obstructions to navigation at low water below St. Louis. The river then flows over the bar in a broad, shallow sheet, with but little more depth in the channel than elsewhere over the bar. The channel generally trends from the Vulcan Iron-Works landing toward the Illinois shore, thence, returning to the Missouri shore a short distance above Jefferson Barracks, following this shore until the foot of Carroll's Island is reached, when it bears again toward the Illinois shore. The bar is mostly composed of sand and gravel, the latter, with some rock, obtaining on the Missouri side, while the former constitutes the bed of the river on the Illinois side. The formation of the Illinois bank is light alluvion, while the Missouri

side is a rocky bluff from the Des Peres to the Meramec, excepting a comparatively small area of alluvion at the mouth of the Des Peres. This latter area, however, is underlaid by limestone rock, which crops out in one or two places at the low-water line.

The bar is subject to change in size and position, varying with different years, although it is always an obstruction to navigation at low water. In the consideration of a plan for the improvement, the entire stretch of river from the lower portion of Carondelet to the foot of Carroll's Island was included.

Obviously, in order to secure the required depth of channel at low water, a contraction of the width of the stream, by means of jetties, dams, &c., must be resorted to, and the amount of contraction should be sufficient to secure the object in view, and yet not so great as to impede the free discharge of floods. The exact amount of contraction will have to be determined by observation as the work progresses, and on this account it seemed better to limit the lengths of the jetties at first, and push them out from time to time as experience may show to be necessary, rather than to construct them of such lengths at the outset that future necessities may call for their curtailment. The minimum width of the low-water channel between Bloody Island and St. Louis is about 1,500 feet, and it now seems likely that this width will have to be eventually adopted wherever the necessities of navigation and commerce demand deep water all the way across. If, however, *both* banks of the river are to be leveed and brought to this distance from each other, the slopes of the levees will be matters of the first importance, in order that sufficient cross-sectional area may be secured for the flood discharges. The projection of any shore-line on the right bank below the river Des Peres must be governed greatly by the proposed wharf-line of Carondelet, and the necessity of keeping open the landing at Jefferson Barracks. A line meeting the conditions thus imposed was adopted, departing by easy curvature from the proposed wharf-line of the city of St. Louis, where it ends at the river Des Peres, and falling into the natural curvature of the rocky shore about one-half mile above the barracks landing. The river will have to be held to this line by means of jetties on the Illinois side of the river, and further held along the Missouri bluff until the foot of Carroll's Island is passed by closing the slough behind the latter, if a tendency to re-open should be developed. At present it is closed at low stages by a sand-bar. The channel will probably regulate its length by erosion below the island.

The first work will be limited to giving the low-water channel a width of 2,400 feet, and watching the effects, instead of bringing it at the outset to the width stated by the board of engineers of February, 1872, as that which may ultimately be demanded for the harbor of St. Louis when extended over this locality, viz, 1,200 feet to 1,500 feet, and for the reason that no present necessity exists calling for deep water all the way across.

The jetties, as originally proposed, were numbered from 1 to 5, inclusive. No. 1, on the Missouri side, 1,300 feet in length, the outer end of which defines the shore-line on that side. Jetty No. 2, on the Illinois side, may possibly not be needed, but of this more can be told as the work progresses. Jetty No. 3 is to be 1,600 feet in length, and is to serve the double purpose of contraction and shore-defense, and also, in connection with jetty No. 4, which is to be 2,600 feet in length, to force the water against the Jefferson Barracks front. The dam (No. 5) for closing the slough behind Carroll's Island would be 2,000 feet in length, and may be required to secure the maintenance of the low-water

channel to the right of the island; jetties and dam to be raised to a height of about 8 feet above low water, which experience shows to be a favorable height for influencing the low-water channel without interfering with the discharge in times of high water. It is possible that short jetties may be required between jetties 2 and 3 and 4, the approximate lengths of which are respectively 300 feet and 600 feet; but as their necessity would arise solely from the insufficiency of the larger jetties to protect the shore properly, a fact which can only become apparent from the effects of the work, their construction is not now contemplated. The same remark may also be made in regard to revetting the head of Carroll's Island, which may eventually become a necessity.

The estimated cost of the works proposed was:

Jetty No. 1, 1,300 feet, at \$18	\$21,400
Jetty No. 3, 1,600 feet, at \$18	28,800
Jetty No. 4, 2,600 feet, at \$18	46,800
Dam No. 5, 2,000 feet, at \$18	36,000
	135,000
Contingencies, add 10 per cent	13,500
	148,500

Operations were commenced on the 15th of August, or as soon as the high water would permit, under a contract with the lowest bidder, Mr. Thomas M. Hackett, authorized by your letter of July 3, 1873. (For abstract of bids, see Report of Chief of Engineers, 1873, pages 451, 452.) The work was carried on by the contractor, Mr. Hackett, until the 6th of October, when, he proving incompetent to go on with the work satisfactorily to the Government and agreeably to the terms of his contract, the same was annulled under the authority of the Chief of Engineers, dated September 20 and 29, 1873, and the work prosecuted by the purchase of material in open market and the hire of the necessary labor.

Authority also having been obtained from the War Department, the stone was quarried from the Government tract at Jefferson Barracks.

The plan of the dikes in general is the same as that illustrated in last year's report on the dam or dike for closing Alton Slough, (see Report of Chief of Engineers, 1873, page 442,) and like that for Venice Dike, (see sketches annexed to report of Assistant Civil Engineer D. M. Currie, herewith,) namely, a riprap of stone built 8 feet above low water, and superposed on a foundation or platform of brush from 2 to 5 feet in thickness, and of varying width to suit the height of the dike, held in place by piles until loaded; an apron of brush about 2 feet thick, also held in position by piles and stone, having been previously laid below and alongside the dike, though not connected with it, to prevent the dike from being undermined by the fall of the water over it. The banks at the Illinois shore, which is of an alluvial character, were protected from wash around the ends of the dikes by a small dike 250 feet long built parallel to the shore and at the foot of the bank; and, further, by a spur-dike being built from each end of the dike back and over the bank for a distance of about 100 feet. In addition to this, the main dike itself was carried back over the bank not less than 200 feet.

The main dikes at top have been left 5 feet wide, and the stone, when thrown in, was allowed to take its natural slope.

The work during the year, the details of which will be found in the report of Assistant Engineer Charles S. True, herewith, may be summed up as follows:

Dike No. 1, extending from the Missouri shore 1,171 feet, and 8 feet high above the low water of 1863, completed.

Dike No. 3, extending from the Illinois shore 1,408 feet, and 8 feet high above low water, nearly completed.

Dike No. 4, extending from the Illinois shore 1,126 feet, mainly completed.

The dikes in progress will be completed during the present season, and when their influence is developed at low water, it is probable that another dike will be located and commenced to extend and secure the results obtained.

NEW WORKS PROPOSED.

Improvements at other points are contemplated during the present fiscal year to the extent of the means available, selecting the localities where the obstructions to navigation are most formidable. Following the general principle that the first step in the improvement at any locality is the collection into a single channel of the whole low-water discharge of the river, the work for this season will chiefly be confined at new points to the closing of island chutes. In my report for last year (page 450, Report of Chief of Engineers, 1873) I suggested that it would be advisable, on the score of economy, that the United States should own the principal working appliances which must be used. Experience of the past year has demonstrated this course to be a necessity to the efficient conduct of the work.

Having been compelled to purchase for use on the work a tow-boat, several barges, three pile-drivers, and the tools required in quarrying stone and handling material, it is the intention to use this equipment during the present year, and to make such addition thereto as may be required for the efficient prosecution of the work. The act approved June 23, 1874, providing only \$185,000 applicable to the improvement of the river from the Missouri to the Ohio, the number of new points where work can be undertaken this year will be limited to two, namely, Turkey and Devil's Islands. These places are now the worst obstructions between St. Louis and Cairo. The present appropriation, it is hoped, will secure as decided an improvement at these points as has been gained at Horsetail Bar, where, though the works already projected are incomplete and others are yet to be located, the depth of water in the channel is considerably greater than was found at the same stage of water last year.

SURVEYS AND TRIANGULATION.

At the beginning of the fiscal year a party was in the field, in charge of Assistant Engineer I. D. McKown, and had carried the triangulation about thirty miles below St. Louis. The work continued until the latter part of October, when the triangulation was suspended for the season, and the party directed to make special surveys at Devil's, Liberty, and Turkey Islands, Horsetail Bar, and Twin Hollows. These special surveys were completed November 30, 1873, when the party was withdrawn from the field and the survey-boat Arkansas laid up.

The assistants were occupied during the winter in completing and making a projection of the triangulation, giving as the present result a skeleton map filled in with sketched topography, except where the special surveys afforded the detail.

The party was re-organized on the 1st of May, 1874, and at the close of the fiscal year had arrived within seven miles of the mouth of the Ohio.

A special survey was made during May and June, 1874, to determine

the facts, and to correctly connect the present and proposed wharf-line of the city of St. Louis with our surveys. Questions of considerable moment to the general interests of navigation and the exercise of the right of conservancy may be required on the part of the United States. The surveys are complete, and are being plotted in the office. It is deemed advisable to defer the discussion of the subject until the water affords an opportunity to make additional observations.

The surveys ordered during the present season, under the allotment of \$10,000 from the appropriation, approved June 23, 1874, for surveys and estimates for the improvements recommended by the Senate Committee on Transportation-Routes to the Seaboard, will be of the character of detailed examination of points where obstructions to navigation are known to exist.

The necessity for a triangulation of the valley proper of the river was shown in the report of 1873. I would respectfully renew the recommendation of the appropriation of \$50,000 for this purpose.

Estimates of the cost of completing the improvement of the Mississippi River between the Illinois and Ohio rivers cannot be given. The surveys of the present season will enable me to submit estimates of the cost of removing present obstructions to navigation, but such estimates cannot be expected to cover all that will be required to complete the improvement of a river subject to so many changes as is the Mississippi.

The detailed surveys made during the past season enable me to approximately estimate the cost of works now required at several of the worst places on the river. To improve the navigation at the points where improvement is most urgently demanded, and to carry on the works heretofore undertaken, will require, for the fiscal year 1875 and 1876, the sum of \$600,000, the appropriation of which sum is recommended for the improvement of the Mississippi River between the mouths of the Illinois and Ohio Rivers, the distribution of the sum to be at the discretion of the Chief of Engineers.

I am indebted to Hon. John F. Long, surveyor of customs of the port of St. Louis, for certain statistics given in his letter of the 28th of July, 1874, accompanying and forming a part of this report.

Referring to the letter of Mr. Long, I would call attention to the increase of tonnage as conclusive refutation of the oft-repeated assertion that the tonnage on the Mississippi is diminishing, the total increase being 39.7 per cent. of the tonnage of 1870. The steamboat tonnage having increased from 71,489 in 1870 to 76,829 in 1874, or 7.4 per cent., and the barge tonnage during the same period increased from 25,634 to 58,860, or 129.6 per cent., shows that while steamboat tonnage is increasing, the growth of the barge interest is in a much greater ratio. The demand for cheap transportation is doubtless the cause of the ratio being so greatly in favor of barges; but the improvement of the navigation by the removal of dangerous obstructions during the last six years or more, has furnished the opportunity for the change, by rendering barge navigation safe.

The works now in progress and contemplated in the portion of the river under my charge will still further facilitate the cheapened transportation by removing the occasion of delays. Removing the causes of danger and delay, the result will be a safe and expeditious transportation, which is synonymous with cheap transportation.

It is impossible to state in detail what amount of commerce and navigation would be benefited by the completion of the above improvements. Suffice it to say that the whole Mississippi Valley would be greatly benefited thereby.

Financial statement.

Balance in Treasury of United States July 1, 1873:

On account of appropriation for improvement of Mississippi River from the Missouri to the Meramec, approved June 10, 1872.....	\$42,000 00	
On account of appropriation for improvement of Mississippi River from the Missouri to the Ohio, approved March 3, 1873.....	197,000 00	\$239,000 00
On account of appropriation for improvement of Mississippi River from the Missouri to the Meramec, approved June 10, 1872.....	15,981 33	
On account of appropriation for improvement of Mississippi River from the Missouri to the Ohio, approved March 3, 1873.....	1,550 00	17,531 33
Amount appropriated for improvement of Mississippi River from the Ohio to the Illinois, by the act approved June 23, 1874, \$200,000, less \$15,000, to be expended between the Missouri and Illinois.....	185,000 00	
Amount allotted from appropriation, approved June 23, 1874, for surveys and estimates for the improvements recommended by the Senate Committee on Transportation-Routes to the Seaboard, &c., to be expended in the survey of that portion of the Mississippi route lying between the mouth of the Illinois River and the mouth of the Ohio River.....	10,000 00	195,000 00
Amount expended during the fiscal year ending June 30, 1874:		
On account of appropriation for improvement of Mississippi River from the Missouri to the Meramec, approved June 10, 1872.....	\$40,360 09	
On account of appropriation for improvement of Mississippi River from the Missouri to the Ohio, approved March 3, 1873.....	174,987 53	215,347 62
Amount available July 1, 1874:		
On account of appropriation for improvement of Mississippi River from the Missouri to the Meramec, approved June 10, 1872.....	17,621 24	
On account of appropriation for improvement of Mississippi River from the Missouri to the Ohio, approved March 3, 1873.....	23,562 47	
On account of appropriation for improvement of Mississippi River from the Ohio to the Illinois, approved June 23, 1874, \$200,000, less \$15,000, to be expended between the Missouri and Illinois.....	185,000 00	
On account of allotment from appropriation, approved June 23, 1874, for surveys and estimates for the improvements recommended by the Senate Committee on Transportation-Routes to the Seaboard, &c., to be expended in the survey of that portion of the Mississippi route lying between the mouth of the Illinois River and the mouth of the Ohio River.....	10,000 00	236,183 71
Amount required for the fiscal year ending June 30, 1876, for improvement of the Mississippi River between the mouths of the Illinois and Ohio Rivers.....		600,000 00
For triangulation of the valley of the Mississippi River between the mouths of the Illinois and Ohio Rivers.....		50,000 00

Report of Mr. D. M. Currie, Assistant Engineer.

ST. LOUIS, MO., July 15, 1874.

SIR: I have the honor respectfully to submit the following report of progress made upon works for the improvement of the Mississippi River at Sawyer and Venice Bends during the fiscal year ending June 30, 1874:

The contract that was awarded to Thomas M. Hackett at the opening of bids in this

office on the 26th day of June, 1873, and of which the abstract was published in the report of the Chief of Engineers for that fiscal year, page 451, for the continuation of the work for improving the Mississippi River at Sawyer Bend under the allotment made for that purpose from the appropriation by act of Congress approved March 3, 1873, was duly entered into by him on the 16th of July following.

Surveys were made of that part of Sawyer Bend lying between the upper end of the works constructed last year and the mouth of the Gingrass Creek in the latter part of July and first part of August, to determine what, if any, changes were necessary to be made in the location of the works or details of the plans. The only change that was made was a slight revision of the location of the longitudinal retaining dike, to make it conform as nearly as possible to the contour of the river-bank, upon which the river had encroached about 30 feet since the surveys were made in August, 1872.

The plan followed in constructing the protecting works was the same as adopted in the construction of similar works at that point during the year ending June 30, 1873, namely, to build a longitudinal retaining dike parallel with the direction that it was intended to give to the bank below mean low-water, and connect this dike with the top of the bank by cross-dikes, built at such intervals as would protect the intervening bank against erosion.

The interval between the dikes that have been built is 120 feet, and, so far as can be seen at this time, they furnish all the protection desired, but if the same system of protection is continued on the remainder of Sawyer Bend, it will become necessary to determine anew the spaces that will be protected by the cross-dikes, because the current impinges against that part of the bank more directly. They vary directly as the product of the length of the dike into the natural cosine of the angle included between the axis of the impinging current and the bank.

To illustrate, let u = the space protected, x = the length of the cross-dike, y = the natural cosine of the angle included between the axis of the impinging current and the bank, and c = a constant whose value is equal to the space protected per unit of dike when the axis of the current is parallel to the bank.

Then $u = c \times y$. If we make $y = 1$, the axis of the current becomes parallel to the bank, and the space protected varies as x . If we make $y = 0$, the expression $c \times y$ reduces to 0, which shows that when the axis of the current is perpendicular to the bank the spaces between the cross-dikes reduces to 0, and that the system of protection becomes a continuous revetment.

The formula $u = c \times y$ furnishes an easy method of determining the space that cross-dikes will protect when the value of c is known.

Mr. Thomas M. Hackett commenced work under his contract on the 21st of August, which was as early as was practicable to do so, on account of the high stage of water that prevailed prior to that date. Even then the water was too high for the dredge to open the trench deep enough for the reception of brush in the foundation of the longitudinal dike, which, according to the plan adopted, was necessary to be done before the construction of the dikes could be commenced; therefore, these operations were necessarily confined to removing a salient point of the bank that projected across the line of the longitudinal dike, near the upper end of the works constructed during the preceding year, while the water remained too high for the dredge to reach the bottom of the trench. It was evident that to enable one dredge to open sufficient length of trench during the season it would have to be pushed to its utmost capacity, and the contractor was permitted to run it night and day. It was unsafe to work all night, however, under a caving bank, and he was able to make only about 16 hours of actual work per day. The dredge with which he commenced work, the *Sam Vansant*, was hired from H. S. Brown, and completed its term of service on the 6th of September, and from that time to the 16th, when he purchased one, no work was done.

The water reached a stage sufficiently low to render it practicable to commence constructing dikes on the 18th of September, but the contractor was not ready to commence delivering brush and stone in the work until the 3d of October, and then not in such quantities as was desired or that would indicate that he would be able to accomplish any considerable amount of work before the approaching winter would close all our operations on the river for the season.

He was at that time dividing his time and means between this work and that at Horsetail Bar, and was thus trying to carry more work than his means justified. About that time, however, you relieved him from further responsibility of the work at Horsetail Bar, which enabled him to concentrate all of his means and energies here, and told beneficially upon the progress that he made with this work after the 15th of October.

The United States furnished him a pile-driver for the work done during October, one driver being used at both Sawyer and Venice Bends, but after that he was required to furnish one to work under his contract, because one driver could not drive piles fast enough to keep the work moving without interruption at both places.

The progress that was made with the work in the latter part of the season exceeded our most sanguine expectations. This was due more to the unusually fine weather for

working that prevailed in the latter part of November and first of December than to any special effort on the part of the contractor, who, though probably doing the best that he could under the circumstances, was so cramped in his movements for want of means that he could not prosecute the work with any great vigor, and frequently the dredge had to stop working because he was not able to furnish the materials necessary to follow up the opening of the trench with the construction of the longitudinal dike.

The dredge was discharged on the 28th of November, and the last brush of the season placed and sunk on the 1st of December. The contractor continued delivering stone and constructing the longitudinal and cross dikes until the 15th of December, when the river rose to 15.5 feet above low-water and submerged his quarry. Before it fell again sufficiently for him to resume work, the navigation became so hazardous that it was found necessary to suspend for the season. Soon afterward he was paid the retained percentage and other dues on account of his contract, and relieved from its further responsibility. The result of the season's operations is: 2,520 feet of longitudinal dike built, as shown on accompanying map, (A B,) which, being added to that built during the preceding year, and that undertaken by the board of water-commissioners of the city of St. Louis, makes 5,445 feet of the two miles recommended by the board of engineer officers.

The following statement shows the cost of labor and materials used in constructing 2,520 feet of longitudinal dike:

Items and quantities.	Contract price.	Amounts.
1,327 1/2 hours of actual work of dredge and crew.....	\$9 00	\$11,135 25
4,406 linear feet of pile-timber.....	6	389 88
124 piles driven 6 feet, (driver furnished by United States).....	2 00	248 00
124 linear feet of piles driven in excess of 6 feet, (driver furnished by United States.).....	30	37 10
124 piles driven 6 feet, (driver furnished by contractor).....	4 00	480 00
6 linear feet of piles driven in excess of 6 feet, (driver furnished by contractor)...	30	1 80
8,310.99 cubic yards of stone as wet riprap.....	1 40	11,615 39
945.73 cubic yards of stone as dry riprap.....	1 50	1,418 59
15.9 cubic yards of earth, (dry excavation).....	30	3 18
1,642.26 cords of loose brush, second grade.....	2 40	8,741 66
86 hours' labor of men trimming bank preparatory to dredging.....	25	21 50
Total amount.....		33,642 35

Bids were received and opened in this office on the 9th of July for furnishing and delivering materials, and doing all the work required for the improvement of the Mississippi River at Sawyer and Venice Bends under the unexpended balance of the appropriation for the improvement of the Mississippi River between the Missouri and the Meramec, made by act of Congress approved June 10, 1872, and the contract was awarded to Messrs. Martin Keary & Bros., they being the lowest bidders. They entered into contract on the 21st of the same month. No work was done under that contract, however, although it was in force until the 6th of October, when you found it necessary to annul it for non-fulfillment of its terms on the part of the contractors; after which the work at Sawyer and Venice Bends under that appropriation was carried on by hiring labor and purchasing materials in open market.

SAWYER BEND.

The work was commenced at Sawyer Bend on the 27th of October, and continued, with slight interruptions, until the close of the year, and consisted in completing and repairing the work done during the year ending June 30, 1873, and in building cross-dikes for the protection of the bank, stone for which was obtained from quarries on the river, and transported on barges while navigation remained open, but after its close it was obtained from a quarry on Broadway in this city, and hauled on wagons to the work.

The results of the operations during the year are:

The works left unfinished at the close of the preceding year were completed; those that were damaged by high-water were repaired; and 21 cross-dikes were built for the protection of 2,520 linear feet of bank, shown on the accompanying map between the points marked A and B.

Protection by cross-dikes instead of by continuous revetment, was adopted on account of the satisfactory results obtained when they were tried as a temporary expedient, and has stood the test of two high-water seasons, proving itself a sufficient protection at a less cost.

The amount of money expended for labor and materials used in the construction of

21 cross-dikes, and the repairs and the completion of works, is shown in the following statement:

Items and quantities.	Price.	Amount.
3,581.17 cubic yards of stone as dry riprap.....	\$1 39	\$4,977 88
3,875.22 cubic yards of stone as wet riprap.....	1 37	4,921 32
203.37 cubic yards of spalls.....	1 34½	271 16
2,124½ hours' labor of men.....	22½	478 01
Total.....		10,648 31

VENICE BEND.

The work at Venice Bend was raising and extending Long Diike, and was in continuation of that commenced there during the fiscal year ending June 30, 1873.

Peculiar interest attaches to the extension of that dike, on account of the difficulties which had to be overcome in its construction. I therefore submit with this report diagrams showing the plan of its construction in detail. This plan is slightly modified from that originally intended, in this, that whereas the original contemplated having the cross-dike or T extended below as well as above the main dike, the upper branch only has been built; and as there is no scour below now, it is hoped that it will not be necessary to build that branch. Of this, however, nothing very definite can be said until after a low-water season shall have passed. If no scour exists, then a great saving will have been made in the cost of the dike by leaving off the lower branch of the T, and if scour sets in we will have only to build it as originally contemplated, and with no more difficulties or expense than would attend its construction now.

The work was commenced on the 14th of October and pushed as rapidly as materials could be procured, and the necessary labor performed with the means at hand, until the 15th of December, when the high water rendered it impracticable to work; and before the flood passed the navigation became so hazardous that we had to suspend operations, not, however, until we had completed the foundation of the extension, including the upper branch of the T.

The work was resumed on the 10th of April, but, on account of the tempestuous weather and high water, very little progress was made until after the 1st of May, when, the weather and stage of water being favorable, the work was pushed and good progress made until the 10th of June, when the high-water and consequent strong current caused a suspension until the 26th, when it was resumed.

The results are: The old dike is raised to 14 feet above low-water, and of the extension the foundation is all in, the construction of the dike well advanced, and the upper branch of the T built.

The following statement shows the expenditures made for labor and materials used in raising and extending Long Diike during the year:

Items and quantities.	Price.	Amount.
12,557 linear feet of pile-timber.....	\$0 06	\$753 42
1,660.65 cords of loose brush, second grade.....	2 10	3,477 36
3,155 cubic yards of stone as wet riprap.....	1 47	4,636 85
6,112.39 cubic yards of stone as dry riprap.....	1 39	8,496 29
4,202.5 linear feet of piles driven.....	25	1,050 63
15.5 hours' labor of men.....	22	3 41
164.5 hours' labor of men.....	22½	37 01
Total.....		17,834 90

Accompanying this report are two tracings, one a map of part of St. Louis Harbor, showing location of the works referred to at Sawyer and Venice Bends, scale 1/1000; the other, plan and sections of the extension of Long Diike, Venice Bend showing details of construction; scale of plan showing entire dike, 1/1750; scale of detail plan and sections, 1/125.

Very respectfully, your obedient servant,

D. M. CURRIE,
Assistant Engineer.

Col. J. H. SIMPSON,
Corps of Engineers, U. S. A.

Abstract of proposals for the improvement of the Mississippi River at the northern harbor of St. Louis, opened at engineer office, United States Army, St. Louis, Mo., July 9, 1873.

Bidders' names and residences.	Guaranteed.	Certified.	Loose brush 1st grade, 1,000 cords.		Loose brush 2d grade, 2,000 cords.		Rafted brush, 1,000 squares.		Pile-timber, 15,000 feet.		Stone for dry riprap, 8,000 cubic yards.		Stone for wet riprap, 12,000 cubic yards.		Spalls, 3,000 cubic yards.	
			Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.
Thomas M. Hackett, St. Louis, Mo.	Yes.	Yes.	\$3 00	\$3,000 00	\$3 75	\$5,500 00	\$6 00	\$6,000 00	\$0 06	\$900 00	\$1 50	\$12,000 00	\$1 50	\$18,000 00	\$1 50	\$4,500 00
Barker, Whittlesey & Co., Fayetteville, N. Y.	Yes.	Yes.	4 00	4,000 00	3 00	6,000 00	6 00	6,000 00	04	600 00	2 00	16,000 00	2 00	24,000 00	1 00	3,000 00
Richard J. Tunstall, St. Louis, Mo.	Yes.	Yes.	3 50	3,500 00	3 00	6,000 00	5 50	5,500 00	06	900 00	1 75	14,000 00	1 60	19,200 00	1 00	3,000 00
Willard Johnson, Fulton, N. Y.	Yes.	Yes.	3 50	3,500 00	3 50	7,000 00	6 00	6,000 00	06	900 00	2 00	16,000 00	2 00	24,000 00	1 50	4,500 00
Martin Keary & Bros., St. Louis, Mo.	Yes.	Yes.	2 89½	2,895 00	2 09	4,180 00	2 47½	2,475 00	05½	825 00	1 39	11,180 00	1 27½	15,300 00	1 35½	3,975 00
Bidders' names and residences.	Gravel, 3,000 cubic yards.		Excavation, dry, 20,000 cubic yards.		Transportation of stone, 2,000 cubic yards, 100 feet.		Piles driven 6 feet, 600 piles.		Piles driven in excess of 6 feet, 1,200 feet.		Labor of men, 1,000 hours.		Labor of teams, 800 hours.		Total.	
	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.
Thomas M. Hackett, St. Louis, Mo.	\$2 00	\$6,000 00	\$0 20	\$4,000 00	\$0 09	\$180 00	\$2 00	\$1,200 00	\$0 25	\$300 00	\$0 25	\$250 00	\$0 50	\$400 00	\$62	\$230 00
Barker, Whittlesey & Co., Fayetteville, N. Y.	1 00	3,000 00	40	8,000 00	10	200 00	4 00	2,400 00	15	180 00	25	250 00	40	320 00		71,910 00
Richard J. Tunstall, St. Louis, Mo.	1 05	3,150 00	20	4,000 00	10	200 00	2 00	1,200 00	20	240 00	35	350 00	70	560 00		61,800 00
Willard Johnson, Fulton, N. Y.	1 00	3,000 00	30	6,000 00	10	200 00	36	216 00	15	180 00	25	250 00	50	400 00		72,146 00
Martin Keary & Bros., St. Louis, Mo.	2 19	6,570 00	19	3,800 00	02	40 00	2 07½	1,243 00	17½	210 00	22½	225 00	42½	340 00		53,200 00

Report of Mr. Charles S. True, Assistant Engineer.

ST. LOUIS, Mo., July 14, 1874.

SIR: I submit to you the following report of work done under my supervision during the fiscal year ending June 30, 1874, for the improvement of the steamboat channel of the Mississippi River, at Horsetail Bar, which work was placed in my charge July 18, 1873.

On the 22d of July, 1873, the day your plan for the year's work was approved, the river was too high for work to be done advantageously, but about that time the water commenced falling rapidly.

A reconnaissance of that part of the river, including Horsetail Bar, made on the 11th and 12th of August, by Maj. C. J. Allen, Mr. R. E. McMath, and myself, showed that the water of the river at that time was too much diffused over the broad sandy bottom to mark out for itself any well-defined low-water channel. The water divided into three principal parts just below the southern limit of St. Louis, one portion following the Missouri shore into the bend below the mouth of the river Des Peres, a larger part crossing the gravel head of Horsetail Bar in a broad sheet too shallow for steamboat navigation, then flowing in a deep channel near the Illinois shore to the head of Carroll's Island, where it divided into two parts, one to go down the chute to the east of the island, and the other to again join the main river below Jefferson Barracks, while the main and only navigable part of the river passed between the high sand of Horsetail Bar and the rocky Missouri shore on which Jefferson Barracks stands.

The river had fallen to 12 feet above the low-water of 1863 on the 12th of August, and material could be profitably used in the construction of the proposed dikes. The contractor, Mr. Hackett, was therefore ordered to begin work immediately, and on the 15th of August he commenced operations. The first rock was put into dike No. 1 on the 19th of August, and dike No. 4 was begun September 5.

Three pile-drivers, built for work on the improvement of the Mississippi River, were turned over to the contractor at Horsetail Bar August 22, and on the 8th of September pile-driving at dike No. 1 was commenced. Three hundred feet of the western or Missouri end of this dike is founded on solid rock, while all the outer portion rests on sand. The part founded on rock was built in a narrow ridge raised 8 feet above low-water, the top finished 5 feet wide, and the sides sloped at an angle of about 45°. On the sand foundation, where piles could be driven, an apron of green brush, 2 feet thick and 25 to 30 feet wide, was laid just below the dike, to prevent the overflow of water from undermining it. To hold this brush in the current and admit of its being sunk in its proper place two rows of piles were driven, 10 feet apart, and with the piles 7 feet apart in the rows; the brush was then placed on top of the water, interlaced among the piles, and loaded with rock till it sunk to the bottom, and enough additional rock was put on to hold it in place. A heavier mat of brush was put in as a foundation for the main part of the dike, and held in place by one row of piles. Rock was put on this foundation till the dike was raised 8 feet above the low-water line of 1863, and finished 5 feet wide on top.

At the outer or channel end of dike No. 1 a cross-dike or T-head, 75 feet wide and 210 feet long, was built on a foundation of brush. To lay this foundation, piling was driven in rows across the T-head, beginning at the down-stream end, and the brush was put in in sections. This part of the work was done in a strong current of water from 12 to 20 feet deep, and the brush was put in and sunk in thin layers, as the piling would not stand against the pressure of a large body of brush.

During the month of September the weather was fine and the stage of water the best that could be had for successful work on the dikes. Everything that could be done by the officers of the Government in charge to hasten the work was done, yet the progress made was not as great as was desirable. Before the foundation of the T-head was in, or that of the main stem of dike No. 1 finished, it became evident that the contractor could not carry out his contract, and that sooner or later he must suspend work entirely. Foreseeing this, you had asked for authority to annul the contract and to continue the work by purchasing material and labor in open market, if it should become necessary to do so. At the close of September it was decided to annul the contract, but Mr. Hackett was allowed to continue work till the 6th of October and until arrangements could be perfected for continuing the work by the hire of labor and purchase of material in open market.

By application through the Chief of Engineers authority of the Secretary of War to quarry rock for the work on the Government reservation at Jefferson Barracks was granted October 2, 1873. On the 7th of October a steam tow-boat was chartered, with the privilege of purchasing her, and two barges were bought and six hired, to transport brush and stone; and on the 8th work was resumed by the United States on the main stem and T-head of dike No. 1 and on the shore ends of dikes No. 3 and No. 4.

The eastern ends of dikes No. 3 and No. 4 were built on a steep bank of alluvion, and the bodies of the dikes were founded on sand. To prevent the water washing around the shore ends, a small dike 250 feet long was built parallel to the shore at the foot of the bank, and three spur-dikes were built from this over the top of the bank.

The main parts of dikes No. 3 and No. 4 were carried out in line with the central spur-dikes, and were built with aprons and foundations of brush similar to dike No. 1. As necessity for more barges arose, two were hired and four bought for the work, and on the 1st of December the steamer Anita, which had been chartered for a tow-boat, was bought by the Government.

In the latter part of November the outer end of dike No. 3 reached the deepest part of the eastern channel, where the water was 25 feet deep and the current quite strong. The work of putting in piling and brush there was slow, and it was decided to continue the dike of rock only. An apron of small stone, some two feet thick and extending 70 feet below the line, was first laid, and the dike raised by putting in rock on line and letting it find its own slope.

A rapid rise in the river began December 10, and on the 13th the water was so high as to stop all work. The chartered barges were returned to their owners and the Government boats and barges all laid up in a safe winter-harbor.

The work done during the season of 1873 was: Dike No. 1, completed. Of this dike 416 feet was built wholly of rock and 755 feet was built with a brush foundation. Dike No. 3 had its shore end built of rock, 400 feet of the main dike finished on a brush foundation, and a foundation of small rock carried out 250 feet further. Dike No. 4 had shore end built of rock, 525 feet of brush apron, and foundation put in, and the dike on it nearly completed.

During the winter some work was done on the steamer Anita, and barges No. 1, No. 3, No. 4, and No. 5 were docked and recaulked. The river remained open all winter.

Work at the quarry was commenced again the 7th of April. The foundation of dike No. 3 was extended to the sand-bar, of rock only, and the dike has since been raised to nearly its full height. Work on dike No. 4 was begun May 20, and a rock apron was built out 400 feet. The stage of water during the spring and thus far during the summer has been uncommonly low for the time of year, and favorable for work in the river.

The condition of the dikes June 30, 1874, was: No. 1, completed; and it stopped the lower currents from following the Missouri shore, and thus concentrated the water in the main channel. Dike No. 3 joined the main Illinois shore and the sand-bar, and had assumed the nature of a dam. It was not raised to its full height, but it had the effect of stopping a large part of the water that otherwise would have gone down the chute and forcing it back into the main channel. Dike No. 4 had not been extended far enough to have any action on the main channel, and acted only as an auxiliary to No. 3 in stopping the channel next the Illinois shore.

The lengths of dikes built and the total amount of material put into them during the year are:

Dike No. 1, 416 feet, of rock only, and 755 feet of rock on brush foundation, using 1,755.25 cords brush, 11,149 linear feet of pile-timber, 12,323.78 cubic yards rock for riprap.

Dike No. 3, shore-end 208 feet, built of rock, 400 feet of main dike of rock on brush foundation, and 900 feet partly built of rock only, using on the dike 371.80 cords brush, 7,053 linear feet pile-timber, 16,983.35 cubic yards rock for riprap.

Dike No. 4, shore-end 201 feet long, of rock, 525 feet of main dike nearly completed, of rock on a foundation of brush, and 400 feet of rock foundation put in for extension of dike, using 792.26 cords brush, 8,064 linear feet pile-timber, 10,278.68 cubic yards rock for riprap.

I have the honor to be, most respectfully, your obedient servant,

CHARLES S. TRUE,
Assistant Engineer.

Col. J. H. SIMPSON,
Corps of Engineers, U. S. A.

Commercial statistics.

CUSTOM-HOUSE, ST. LOUIS, MO.,
Surveyor's Office, July 28, 1874.

Sir: Respectfully acknowledging receipt of your communication of 24th instant, I would reply to its inquiries as follows:

1. St. Louis is a port in the collection-district of New Orleans, though entirely independent of that port.

2. The revenue collected through this office for the year ending June 30, 1874, was \$1,434,224.75, from the following sources:

Import duties	\$1,407,910 33
Steam-vessel inspections	15,471 62
Hospital fees from seamen	10,842 80

The tonnage of this port at this time is as follows:

	No.	Tons.
Steam-vessels	170	76,829
Barges	161	58,860
Total	331	135,689

Which compares with the tonnage in the year 1870 as follows:

	No.	Tons.
Steam-vessels	166	71,489
Barges	70	25,634
Total	236	97,123

This comparison is interesting, too, as showing the growth of barge-transportation; a growth which will, in my opinion, be more rapid still from this time forward.

Trusting the foregoing may be of some slight service,
I am, very respectfully,

JOHN F. LONG,
Surveyor of Customs.

Col. J. H. SIMPSON, *U. S. A.*

K 2.

IMPROVEMENT OF OSAGE RIVER, MISSOURI.

The plan of operations for improving the Osage River during the fiscal year ending June 30, 1874, was the same as that followed during the preceding year, viz, the construction of cross-dams and training-dikes, together with the excavation of the channel, with a view to obtain at all times, if possible, a depth of water at the shoalest parts of at least 2 feet at the lowest stage of the river.

As stated in my report for last year Mr. Howard Cook, the contractor for dredging, having procured a dredge which he felt confident would perform the work under his contract, asked for an extension of time in which to execute the work. This was granted under the authority of the Chief of Engineers, to include the 31st of December, 1873; but after diligent efforts upon his part to carry on the work, he found that he was unable to do so, and asked to be relieved from his contract. Being assured that the retirement of Mr. Cook would not be detrimental to the interests of the Government, as hired labor could do the work more suitably, and, as I believed, at a cheaper rate and with more economy, and as the current caused in the channel by the erection of dams was expected to erode the bottom, and thus diminish the amount of dredging, I recommended that he be relieved from the obligations of his contract. This was granted under date of September 2, 1873, by the Chief of Engineers, and payment made of the amount due thereon.

The entire work then was prosecuted by the hire of labor and purchase of material in open market.

Operations were carried on under a balance of '\$50,594.74 of the three appropriations of \$25,000 each, approved respectively March 3, 1871, June 10, 1872, and March 3, 1873, and the work confined to the improvement of Dixon's Round Bottom, Burd's, Lockett's Island, Lockett's, General Bolton's, and Shipley's Shoals.

At Dixon's Shoal the work previously commenced was continued, and resulted in the completion of a training-dike 2,003 feet in length, 3½ feet above low-water, and with a slope of 1 to 1, on the channel-side, and on the opposite side a slope of 2 to 1, and a flat surface on top of

6 feet in width. A cross-dam extending 583 feet from the right bank, and joining the head of the training-dike, was also built at this point with the same base and slopes, but only having a height of 3 feet above low-water, together with a header 100 feet in length, built up the stream at right angles with the cross-dam and in continuation of the training-dike.

The work at Round-bottom Shoal consisted in building a cross-dam and training-dike, the former being 480 feet in length and the latter 1,200 feet, the channel having a low-water surface of 80 feet in width.

A cross-dam of 440 and a training-dike of 2,640 feet in length were completed at Burd's Shoal, together with the excavation of the channel, securing at this point a channel of 50 feet in width and over 2 feet in depth at low-water.

The work at Lockett's Island Shoal was confined exclusively to deepening the channel by excavation by means of scrapers. The shoal being only 500 feet in length, a channel of 50 feet in width and 2 feet in depth throughout the entire length of the shoal was secured in a short time.

At Lockett's Shoal, which is also only 500 feet in length, a channel of the same width and depth was excavated in like manner.

A wing-dam having been built at the head of General Bolton's Shoal, on the left side of the river, by the State of Missouri, which had not effected an improvement of the river at this point, it was decided to locate the channel along the left bank of the river, tearing away 100 feet of the old dam, and using the balance for a portion of a cross-dam, and to build a parallel wall along the left bank 500 feet above and below the cross-dam. The lateness of the season, however, at which the work was undertaken prevented the possibility of doing more than to remove the 100 feet referred to, and to excavate a channel to the requisite depth along the line selected. This work was prosecuted until the weather suspended operations. Though not successful in obtaining a channel of 2 feet throughout the length of the shoal, a clear water-way of 50 feet in width was secured, with a depth of 2 feet for a distance of 1,300 feet, and 14 inches in depth for the remainder of the distance, 700 feet, which is 7 inches in excess of the depth at any point in the old channel.

The construction of a training-dike 2,050 feet in length and a cross-dam of 1,046 feet in length were commenced at Shipley's Shoal during 1872, but not completed in consequence of the lateness of the season. It was contemplated during 1873 to complete this unfinished work, and extend the training-dike 1,100 feet farther down-stream, in order to reduce the velocity of the current, and, if possible, to remove a bar that had formed at the end of the dike. The foundation for this extension was partly excavated, but the approach of winter caused the extension to be abandoned, and the work confined to the completion and strengthening of that left unfinished at the close of the previous season. The result attained was the completion of 1,110 feet of training-dike and 400 feet of cross-dam, together with an up-stream prolongation of the training-dike for a distance of 100 feet. At this stage of progress work was suspended, on account of the cold weather.

An examination of the work in March, 1874, with a view to ascertain the effects produced upon the channel, developed the fact that the cross-dam at this point was too high, causing, at high stages, too much water to be forced into the width assigned to the low-water discharge. To remedy this, operations were commenced as early as the weather and stage of the river would permit, and at the close of the year 250 feet of the dam had been lowered to a height of $1\frac{1}{2}$ feet above low-water. The material thus removed was used for repairing and lengthening that por-

tion of the training-dike unfinished at the end of the operations of 1873. This, with the aid of a break about 80 feet in width, which had occurred in the old portion of the dam, relieved the extreme current through the chute, and it was decided to discontinue the further lowering of the cross-dam.

The up-stream prolongation of the dike constructed last season was also lowered to an elevation of 6 inches below the new level of the cross-dam, the material taken being used in repairing and strengthening the dam at points where required. A sharp point on the left bank of the river was removed, which secured a straight channel at high water of a width of not less than 125 feet at any point through the entire chute. The channel was also relieved of 62 snags, and 120 trees were cut from the bank.

The back-water of the Missouri suspended further work of repairing and finishing this dam on the 6th of June. Since that date to the close of the fiscal year a force has been employed in getting out the necessary material for completing the work.

For further information relating to the work of improving the Osage River I refer to the report herewith of Assistant Engineer W. S. Simpson.

The act of Congress approved June 23, 1874, appropriated the further sum of \$25,000 for continuing the work of improving the Osage River. My project for the expenditure of this sum was submitted to the Chief of Engineers on the 15th of July, 1874, and approved by him on the 21st of the same month. It involves the continuation of the same system of improvement already followed, namely, the scouring away of the shoals by wing-dams and training-dikes, and the removal of snags and logs from the channel and leaning trees from the banks, using for the purpose, say, \$20,000 of the appropriation, and the balance of \$5,000, or so much of the \$25,000 as may be necessary, for continuing the thorough survey from Tuscumbia (to which point it had already been carried from the Missouri River) up the river towards Roscoe, a distance of one hundred and seventy-three miles, with a view to the permanent improvement of the river by means of locks and dams, if the results of the survey should justify such a mode of improvement; the survey to be made as soon as possible, in order that a project might be submitted to Congress at the earliest moment.

All the work contemplated under this appropriation will be performed, as under former appropriations, by purchasing material in open market and by hired labor.

No estimates for the prosecution of the work during the fiscal year ending June 30, 1876, are submitted with this report, these being delayed until the survey above contemplated has been completed and all the necessary facts ascertained.

The collection-district in which the work is located is New Orleans.

The nearest port of entry is that of St. Louis.

Amount of revenue collected at the port of St. Louis for the fiscal year ending June 30, 1874, was \$1,434,224.75.

Amount of commerce and navigation that would be benefited by the completion of the work is unknown.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$40,000 00
Amount in hands of officer and subject to his check	10,594 74
Amount appropriated by act approved June 23, 1874	25,000 00
Amount expended during the fiscal year ending June 30, 1874	47,332 77
Amount available July 1, 1874	28,261 97

Report of Mr. W. S. Simpson, Assistant Engineer.

JEFFERSON CITY, Mo., July 1, 1874.

SIR: I have the honor to submit the following report of the operations on Osage River, Missouri, for the fiscal year ending June 30, 1874:

On the 2d of June, 1873, orders were issued by you to my predecessor, the late Mr. George R. Eichbaum, to repair to Osage City, Missouri, and inaugurate a system of labor for the improvement of the Osage River. His instructions were to obtain, if possible, at all times a depth of water at the shallowest parts of at least 2 feet, at the lowest stage of the river. This was to be effected under a contract with Mr. Howard Cook, of September 21, 1872, as far as the same applied to the works, and by the construction, with hired labor, of cross-dams and training-dikes, and the use of such other means as his experience might suggest, to accomplish the purpose.

On the 6th of June Mr. Eichbaum reached Osage City with his assistant, Mr. F. P. Schrader, ready to proceed to work; but found that the Missouri River had backed the water up the Osage as far as Round Bottom Shoal, to a depth of 10 feet, and up to the 15th of June the shoals of the Osage River above Round Bottom had from 5 to 8 feet depth of water upon them. On the 18th the Osage had slowly fallen so that the surface of the water at the head of Dixon's Shoal was 3 feet above low-water. The boats, tools, &c., were taken up to the head of Dixon's Shoal, and it was determined to commence operations at this point and work downwards, completing, if possible, all the necessary work between Dixon's and the mouth of the Osage first. A limited force was engaged, and work was commenced in cutting timber and brush and in quarrying stone for the proposed dam at this point; but the river again began to rise, and it was not until the 21st of July that the water was sufficiently low to allow the commencement of the continuation of the cross-dam and training-dike.

During the previous season it had been determined by Maj. C. J. Allen, Corps of Engineers, and Mr. Blaisdell, the engineer in local charge of the improvement, and approved by Lieut. Col. W. F. Reynolds, then in charge of the Department, that the following plan of dam was the best suited to the improvement of this river. Mr. Eichbaum as mentioned in his diary, determined to follow the same in his improvement of this shoal, viz, "to build a training-wall parallel to one bank of the river at the shoal, forming a lateral canal of such a cross-section and length as at the stage of water immediately preceding that of low-water would have such a current that while boats would have no difficulty in stemming it, the channel would be maintained by its own scour after it had once been opened." I would state that this was the plan followed with a little variation for all succeeding dams built after this one.

The dam at this shoal was built giving a width of low-water surface of 85 feet, and was located parallel to the left bank of the river, which made it necessary that the same should be on a slight curvature of 40'. The dam was built of logs, brush, and stone. Brush was first laid at a depth of 14 inches below the surface of the water, and when parallel to the current slightly inclined up-stream, in order the better to catch the material carried down in freshets. The depth of water in which it was placed varied from 0 to 3½ feet; but when the water was not deep enough in every case, a bed was scraped out so that there should be a uniform depth of 14 inches from the surface to the top layer of brush. A single log, varying in character from 2 to 3 feet in diameter was laid on top of the brush and the ends beveled and pinned with wooden pins to a log at each end and similarly placed. Braces were then laid at intervals of a few feet, one end pinned to the log and the other cross-staked on the riverbed. Long brush was again placed on the braces and logs for the purpose of making the bearing-weight of the stone as great as possible. Gravel was then scraped on the brush from the channel to the depth of about 1 foot; stone was then thrown on the logs and brush thus arranged, and the stone then placed in the shape of rubble-work, so as to give the dike a height of 3½ feet above low-water, with a slope of 1 to 1 on the side next to the channel, and on the opposite side a slope of 2 to 1, giving a flat surface on the top of 6 feet in width. Length of training-wall thus built at this shoal was 2,003 feet. In building a lateral wall parallel to the current it is necessary to have a cross-dam connecting it with the shore for the double purpose of confining all the water in the new channel and for security. One was built at the head of this wall, inclining some 4° up-stream from the shore and some 1,795 feet above the point where the old State dam had originally been placed.

The greater portion of this cross-dam was built in water from 1½ to 2 feet deep, and after the logs and brush were placed in position, in the same manner as in the training-wall, (only that the braces were put more closely together and more securely fastened, rendered necessary to resist the current,) the stone was thrown on the logs and brush in the shape of rubble-work with the same base and slopes as in the training-dike, but only to the height of 3 feet above low-water. This dam extends 583 feet from the right bank and joins the head of the training-wall. At the junction of the training-wall and cross-dam a header was built up the stream, at right angles with the cross-dam, 100 feet in length, so as to form with the cross-dam a pocket sufficient to hold all

the material in the shape of gravel and other *débris* which is brought down the river by the freshets, and to prevent the same from going into the new channel.

The surface velocity of the new channel was found to be at low water 2.5 feet per second.

While the work of construction of the dam was going on it was the original intention that the contractor for the excavation of the channel should at the same time perform the excavation needed in the new channel, so that the material excavated could be placed upon the dam, serving at the same time to both strengthen the dam and lessen the quantity of rock required, thus lessening the cost of the work. After repeated trials of his machinery, the contractor became convinced that his dredge-boat would not do the work required. Consequently, on August 7, he abandoned the work and removed his boat to Osage City, and on August 13 he made application to be released from his contract, which after application to the Chief of Engineers was granted, under authority dated September 2, 1873.

The total amount of material removed by the contractor under his contract was 670 cubic yards. The failure of the contractor to perform his allotment of the work necessitated other arrangements. As the river at this time was at its lowest stage, (the surface of water at the head of Dixon's Shoal being only 0.5 above extreme low-water,) it was determined to proceed to the execution of the excavation of the channel by means of road-scrappers and teams. On the 16th of August, a supply of road-scrappers having been received, work was commenced upon the bed of the channel. After a trial it was found that the scrappers would not take hold of the material unless the same was first loosened from the bed of the river. Consequently a plow was brought into requisition, and at first was found would work very successfully, but afterward, when we encountered a muscle-bed in the middle of the channel, it was found, unless pressed down with great weight, that the plow would not take hold, and when it did take hold, would require most of the time three teams of horses to draw it through. The bed of the river at this shoal consisted of hard sand and gravel intermixed with boulders of stone very firmly imbedded in the same, and also of occasional muscle-beds, which rendered it very difficult to remove. It was by far the hardest of any of the shoals to dredge between it and the mouth of the river. I am satisfied that while the dredge built by the contractor would not work on this shoal, because of the hardness of the bottom and the flimsiness of his machinery, if he had tried the same upon any of the succeeding shoals, (except perhaps the shoal at Round Bottom,) it would have been successful.

The work of construction of the cross-dam and training-dike at this point was finished on August 24, 1873, and the work of excavation on September 22, 1873.

ROUND BOTTOM SHOAL.

On account of the shortness of the season on this river during which we would be able to carry on the work of construction, (the most favorable ones not lasting longer than from the first of July to the middle of November,) it was determined to carry on the work of improving several shoals at the same time. As soon, therefore, as the timber-gang had completed their work of cutting sufficient brush and timber for the works at Dixon's Shoal they were moved down to the shoal at Round Bottom, one and one-half miles below that of Dixon's, and on August 7, 1873, the work of constructing a cross-dam and training-dike was commenced at this point. This shoal, though not as long, and with from 4 to 6 inches more water upon it than upon the shoal at Dixon's, still was regarded by steamboat-men to be more difficult to navigate than any shoal upon the river, on account of the old State dam which had been built here, causing a cross-current to such an extent as to compel boats at almost every stage of the water to run a line to enable them to get through in coming up and down the river. To cut off this cross-current it was determined to build a training-wall, 1,200 feet in length, parallel with the right bank of the river, thus securing a low-water channel-surface of 80 feet and a cross-dam 480 feet in length, built in the same manner as the dam at Dixon's Shoal. The surface-velocity of the current was found to be 3.3 feet per second, and I am afraid, from actual trial of the same, that it will be found expedient this season to increase the length of this training-wall several hundred feet, in order to reduce this velocity, which is too great for the smaller class of boats plying on the river. The training-wall and cross-dam were finished on September 11, and the excavation on October 14, 1873.

On September 11, the death of Mr. George R. Eichbaum, the assistant in local charge of the improvement, having been reported to the office, I was directed by you, as per letter of instruction dated September 12, to proceed to Castle Rock and to assume local charge of the works lately under his charge. I arrived at Castle Rock on the morning of the 13th, and immediately assumed charge of the works. I found that Mr. Eichbaum had been seriously ill some two weeks previous to his death and unable to attend to any of his duties, during which time the works had been carried on under the supervision

of his assistant, Mr. F. P. Schrader. Owing to the careful management of Mr. Schrader and his unwearied exertions, I found the works in a much better state than was anticipated. There had been no serious delay or interruption at any time.

After making a careful examination of the works, I determined to carry them on in the same manner as had been arranged by my predecessor. Consequently, on September 14, I commenced the construction of a cross-dam and training-dike at Burd's Shoal, the next one below Round Bottom, and four miles distant.

This shoal has only a depth of water upon it at the head of 8 inches when the river is at its lowest stage, and with a fall of only 2,006 feet per mile. The river at this point is also quite broad. After a thorough examination I determined to run a wall parallel with the left bank of the river, where the deepest thread of water was, and where also the deposited material was the lightest, so that the channel would have a low-water surface of 85 feet. I found it necessary to carry this wall to the length of 2,640 feet, so as to get it into deep water and to give a surface-velocity to water flowing through the channel of 2.5 feet per second. The cross-dam was at right angles to the training-wall, 440 feet in length, but built in the same manner as the works above. This work was finished on October 14, 1873, at which time the excavation of the channel was also finished, and we have now at this point a channel with a width of 50 feet, of over 2 feet in depth at the lowest stage of the river.

LOCKETT'S ISLAND SHOAL.

The next shoal below Burd's is that of Lockett's Island. This shoal is a small one, only some 500 feet in length, and with a depth upon it at all times of from 20 to 22 inches of water. The only improvement contemplated for this shoal was to dredge a channel through the same to the required depth of 2 feet. As soon as the excavation at Round Bottom Shoal was finished the force engaged at that point was moved to this shoal, and the work of excavation was commenced and carried on until October 24, when we had a clear channel the entire length of the shoal, 50 feet in width and over 2 feet in depth. The material of the bed of the river at this shoal, being only soft gravel and sand, was easily removed by the scrapers.

LOCKETT'S SHOAL.

The next shoal below Lockett's Island Shoal is that of Lockett's Shoal; distance from the former about one and one-half miles. As soon as the force engaged at Lockett's Island Shoal were through the excavation of that shoal they were removed to this point. This shoal, like the one above, is a small one, only about 500 feet in length and with a depth of water upon it at all times of from 20 to 22 inches. The only improvement contemplated for this shoal, like the one preceding it, was to dredge a channel through it to the required depth. The work of excavation was finished on November 2, and we now have a clear water-way of 50 feet in width and over 2 feet in depth. The bed of the river at this point consisted only of soft gravel and sand, and was easily removed by the scrapers.

GENERAL BOLTON SHOAL.

This shoal, distant from Lockett's Shoal some two and one-half miles, is one of the largest and shallowest upon the river, and has been made much worse by the attempts that have been made to improve the same in years past, first by a wing-dam, built by the State authorities at the head of the shoal, which was located on the left side of the river, and across the line of the deepest water, with the intention of forcing the water over upon the shoal, so that it would cut a channel around the head of the dam. This has had no effect except to scatter the water over the shoal and lessen the depth upon it. Mr. Livermore made a cut through this shoal around the head of the dam in 1871, and repaired the wing-dam; but very little of his work remains now, the cut having almost entirely filled it up. After a careful examination I determined upon the following plan for the improvement of the river at this shoal: to locate the channel along the left bank of the river, where the deepest thread of water was found, and where the deposited material was the lightest, tearing away 100 feet of the old dam, using the balance for a portion of the cross-dam, continuing the same across the river, and to build a parallel wall along the left bank of the river, some 500 feet above and below the cross-dam. Owing to the lateness of the season and the unusual cold weather of the preceding two weeks I was afraid to undertake the whole of this improvement, and confined myself to tearing away the 100 feet of the old dam nearest to the shoal and excavating a channel to the required depth along the line determined upon, leaving it for another season to determine whether the rest of the works would be required or not. Work was commenced at this point on October 18, by tearing away the portion of the old dam nearest to the shore, and the work of excavation on November 3, and carried on until November 20, when, on account of the cold weather, work was suspended. We were not successful, for this reason, in getting a channel to the required depth of

2 feet through the entire length of the shoal, but we did get a clear water-way of 50 feet in width and with a depth of 2 feet for 1,300 feet, and the balance, 700 feet, a depth of 14 inches, which is better water than there is at any point in the old channel by 7 inches.

The next shoals below Bolton's of any importance, and, indeed, the last on the river, between Bolton's and the mouth, are Shipley's and Brenneker. These shoals are in fact but one, the length of which is 1.4 of a mile, with a fall of 2.144 feet. During the season of 1872 there was commenced at this shoal a training-wall 2,050 feet in length parallel to the left bank of the river, and a cross-dam of 1,046 feet, the channel having a low-water surface of 75 feet, but the approach of winter prevented the completion of the work; a brush and log foundation was merely put in and loaded with enough stone to hold it during the next spring rise of the river. Owing to the incompleteness of the work, which I was satisfied in its present state would not stand another spring rise of the river, and also on account of the back-water of the Missouri River, which for a greater part of the year extends above the shoal, leaving only about four weeks in the latter part of the season when it is possible to work upon the shoal, I was anxious to prosecute this work at the earliest possible moment; and for this reason did not deem it prudent to commence a thorough improvement of the Bolton Shoal this season; but immediately upon the completion of the work at Burd's all of the available force was moved down to Shipley's Shoal. My original intention contemplated extending the training-wall at this locality 1,100 feet further down the stream, for the purpose of reducing the velocity, which is too great for the smaller class of boats plying upon the river, and also, if possible, to carry away a bar which had formed at the end of the wall, and the foundation for the same was partly excavated; but the extreme cold weather which set in about the time compelled me to abandon this, and confine myself to completing and strengthening the work begun last season. He succeeded in completing 1,100 feet of training-wall and 400 feet of the cross-dam. Besides this, there was added at the head of the training-wall an extension of 100 feet, entirely new work, which was placed there for the purpose of checking a cross-current which was found to be at this point, caused by the cross-dam and training-wall coming together on too much of a curve, and also to form a pocket to catch the gravel and other *débris* coming down the river, when the same would be at a stage of about 6 feet above low-water. This work was carried on until November 21, 1873, when, on account of the weather, work was discontinued, under instructions from you dated November 13, and the force discharged, and the boats and other property removed to Osage City, Mo., and placed in charge of a watchman for the winter, when, with my assistant, I returned to St. Louis and reported to you on November 26, 1873. During the months of December, January, and February we were engaged in preparing the map of the work which had been done during the season and placing the same upon the general map of the river, and in making up the detailed estimate of the cost of the work upon the several shoals upon which the improvement had been carried on.

On April 1, 1874, I received instructions from you to proceed to Jefferson City, for the purpose of organizing a party for the prosecution of the work of improving the Osage River, and in the conduct of the same to be guided by recommendations contained in the report of Capt. C. J. Allen, Corps of Engineers, made to you under date of March 27, 1874, and approved by you.

On May 4, 1874, the boats and other property belonging to the improvement were removed from Osage City to the head of Shipley's Shoal, but it was not until the 10th that the water was sufficiently low to allow us to commence active operations. At this date, the water standing at an elevation of only 3.8 feet above low-water, a small party was organized, and the work of lowering the cross-dam at this point was commenced and carried on as recommended in the report of Captain Allen. Up to this time some 250 feet of this dam has been lowered to a height of 1.5 feet above the plane of lowest water. The material taken from this point has been used in repairing and lengthening that portion of the training-wall left unfinished at the close of last season's operations. As the lowering of this much of the cross-dam, together with a break of about 80 feet, which was found to have occurred in the old portion of the cross-dam, has so relieved the excessive current which was complained of in the chute, I have not deemed it advisable to continue the operation of lowering the cross-dam to any further extent. The addition of about 100 feet put in last year has been lowered, as recommended in the report, to an elevation of 6 inches below the new elevation of the cross-dam. The material removed from this point has been used to repair and strengthen the cross-dam.

The sharp point along the left bank, spoken of in the report of Major Allen, has been removed, and in doing this about 600 cubic yards of earth-excavation has been taken from the bank, which gives a straight channel at high-water of not less width at any point than 125 feet through the entire chute. There has also been removed from the channel 62 snags and 120 trees cut from the bank. The work of repairing and finishing this dam at Shipley's Shoal was carried on until June 6. On that date the Missouri River commenced to rise very rapidly, and soon backed the water up the Osage

River, above Dixon's Shoal, some thirty miles from the mouth, so that we were obliged to discontinue the work at this point. From that time to the 30th of June the whole force was engaged in getting out the material required to finish the works at this point.

I feel called upon to say, in closing this report, that I have no faith in the permanency of the above works, inasmuch as the factors of danger are the same on this as on other rivers of the same class. I mean rivers of the same average rapidity of current and crookedness, and with unstable bottoms of mud, sand, and gravel, upon which these same means of improvements have been tried, and almost in every case proving only of a temporary character, and lasting, as I think they probably will in this river, from ten to fifteen years, and leaving the river worse than it was before the improvements were commenced. This river itself presents a case of this kind. About twenty years since, the State of Missouri expended some \$175,000 in improving it by means of wing-dams and dredging, and although the dams were put in in the most reckless manner, and without regard to proper location upon the shoals, the benefit for a short time was very great; but soon the bars formed below the dams, and in ten years the navigation of the river was worse than it was before the improvement was commenced. So far as the permanent improvement is concerned, I am satisfied that locks and dams is the only method that will give continuous and uninterrupted navigation throughout the entire year. There is no doubt that the improvements that have been already made have tended and will still continue to develop the resources of the country lying along and adjacent to the river, and to encourage and increase the cultivation of the land now lying idle, by cheapening the means of transportation, and thus serve to develop the rich mineral deposits, consisting of iron and lead, said to lie higher up the river than we have yet reached. Still I fail to see, from the present or prospective commerce of the Osage River, the necessity at this present time of the General Government undertaking so costly an improvement of this river as that by means of slack-water navigation.

In conclusion, I beg to acknowledge my appreciation of the able services of my assistants, Messrs. Schrader and Winston, the former both in the field and office.

Respectfully submitted.

W. S. SIMPSON,
Assistant Engineer.

Col. J. H. SIMPSON,
Corps of Engineers, U. S. A.

K 3.

INSPECTION OF WORK ON OSAGE RIVER, MISSOURI.

Report of Capt. Charles J. Allen, Corps of Engineers.

ENGINEER OFFICE, UNITED STATES ARMY,
St. Louis, Mo., October 11, 1873.

COLONEL: I have the honor to make the following report of my inspection of the work on the Osage River, made in obedience to your orders of the 6th instant:

I reached Jefferson City on the afternoon of the 7th, where I was met by Mr. Simpson, civil engineer in local charge of the Osage River improvements. It being too late in the day to warrant us in setting out for the river, we left Jefferson City the following morning in a conveyance for Dixon's Shoal, the most distant of the improved shoals from the mouth of the river. Here we took a skiff, and, after inspecting the work at this point, proceeded down the river, examining the work at Round Bottom and Burd's Shoals. Resting for the night at the latter, we resumed our skiff the following morning, and proceeded down the river to Osage City, reaching that place at night, having, in this manner, passed over thirty-two miles of the river.

The works at Dixon's and Round Bottom were laid out by Mr. Eichbaum, and were in successful prosecution at the time of his death. Their completion as well as the laying out of the work at Burd's has been accomplished by Mr. Simpson, engineer in local charge, assisted by Mr. Schrader. The quantity of work done, as well as the lengths of dams put in, is stated by Mr. Simpson in his monthly reports, so that it is not necessary to restate it here. I will merely say that the working parties are well organized and handled, the quality of the work first class, and in quantity a maximum. There is room, however, for difference of opinion as to the extent to which the low-water channel should be contracted, and I will refer to this further on.

An examination of Shipley's Shoal, the lowermost one on the river, showed that the dam constructed last year by Mr. Blaisdell, civil engineer, was in as good condition as could, with reason, be expected, he having been forced by the lateness of the season and the accumulation of ice to leave it in an unfinished state.

It will be remembered that all the shoals, as far up as Dixon's, were dredged, or rather scraped, in 1871, by Mr. Livermore, civil engineer in local charge, and although a large and creditable amount of work was performed by him, the cuts all filled up again, on which account your predecessor decided to use dams, jetties, &c., to keep the cuts open. The Shipley dam appears to have produced good effect towards deepening the channel at that point, but I think that an extension of the work here will become necessary in order to reduce the velocity through the chute somewhat, and also to remove a bar that seems to be forming at the foot of Brenecker Shoal, which is in fact but a continuation of Shipley's.

I discussed this matter fully with the engineer in local charge, who will make further examinations into the condition of the shoal so as to be enabled to decide upon the extension required this season.

At the time of my inspection the stage of water in the Missouri had affected the level in the Osage as far up as Shipley's, so that the exact effect of the work there could not be ascertained, although I am satisfied that it has been of benefit to the channel. To return to the subject of the contraction of the channel by means of dams, &c. The low-water discharge of the Osage is not more than 300 cubic feet per second, flowing, generally, in a broad and very shallow sheet over shoals of hard, flinty, compact gravel, with some sand and, occasionally, mud intermixed, the mud coming from the Missouri when its level is higher than that of the Osage. By the contraction of the water-way, and collection of all the water into one channel of 75 feet in width at low water, we could expect a mean depth of 2 feet, provided the mean velocity did not exceed 2 feet per second. In treating a river like the Osage, whilst we can definitely limit its width, we are not always certain that the resulting depth and velocity will be what we desire. Too high a velocity would retard ascending boats, besides disturbing the bed and carrying the gravels into the very chutes from which we wish to exclude them. The low-water discharge being so feeble, the channel should be, in some measure, prepared for it before the river reaches its lowest stage. And, in the location of the channels or chutes, the softer and more yielding portions of the bed should be, if possible, selected for the low-water discharge to deal with, training the gravels and other hard material into the high-water channels wherever practicable. The reduction of the velocity is, then, the main question. For calculating the velocity we have the ordinary formula:

$$v = \sqrt{\frac{A \times 2 g h}{F \times l p}}$$

in which—

A = area of cross-section;
 h = fall;
 g = acceleration;
 F = co-efficient of friction;
 l = length; and
 p = wetted perimeter.

Putting, for convenience—

$$\frac{A}{p} = r = \text{mean radius};$$

$$\frac{h}{l} = S = \sin;$$

calling—

$$\sqrt{\frac{2 g}{F}} = C;$$

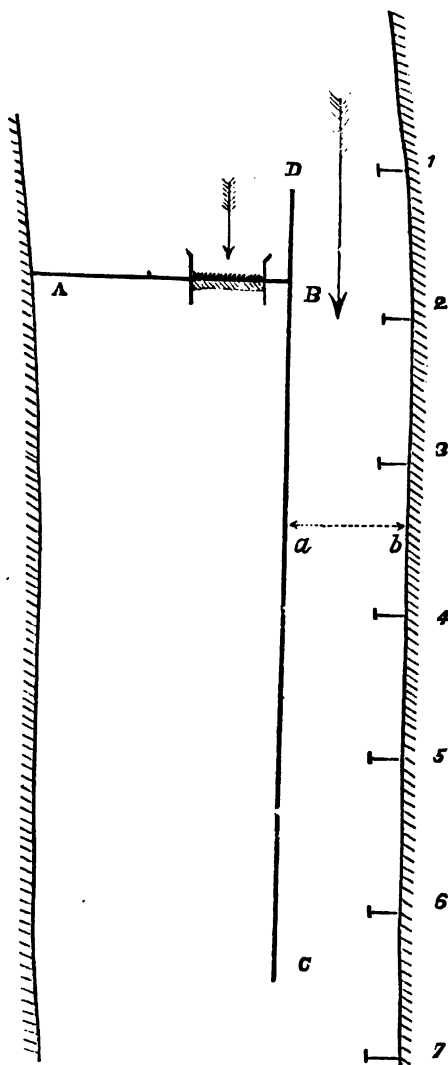
and substituting, we have—

$$v = C \sqrt{r \cdot s};$$

from which it appears that the velocity varies inversely with the length of channel and perimeter. In order, then, to reduce the velocity in the interests of navigation and the stability of the bed, we must increase, at least not shorten, the length of channel for the absolute fall. Whether to use jetties alone, or, as has been done thus far, cross-dikes and training-walls is mainly a matter of comparative cost, although my preference is for the training-walls upon the shoals in question.

Were the material composing the bed of a light and movable nature its removal might be partially accomplished by the use of alternate opposite jetties, leaving the stream to work out its own length between them, as has been successfully tried upon the Wisconsin River.

The required length can be attained by curving the channel, or by running the wall some distance into the deep pools above and below the shoal. This, besides reducing the value of S , would raise the water-surface in the chute. The following sketch will serve as an illustration of the works constructed thus far:



The cross-dike $A B$ serves for contraction, and the longitudinal wall $B C$ for training and securing the channel. As $B C$ is increased in length the velocity should be diminished, and the area of cross-section increased by the elevation of the water-surface. As before stated, the width, $a-b$, adopted by your predecessor for Shipley's was 75 feet. The widths at Dixon's, Round Bottom, and Burd's vary from 110 to 130 feet, as given me by Mr. Schrader. I think that these widths are too great for the small low-water discharge of the Osage. If actual trial demonstrates this to be true, the deficiency can be readily repaired by the construction of a few spurs, as shown at 1, 2, 3, 4, 5, 6, 7, &c., the expense of which would not exceed a few hundred dollars. These spurs, besides contracting the channel, would probably raise the water-surface, consequent upon diminishing the velocity of discharge, upon the Venturi principle.

On the other hand, should actual trial show that the contraction at Shipley's is too great, causing too high a velocity, and it not being desirable to carry on any works below Brenecker for the purpose of further elongating the channel, the discharge through the chute can be reduced by sluicing off some portion of it through the cross-dike as indicated in the sketch, provided the withdrawal of such quantity is not followed by a decrease in the cross-section.

In the first report made upon this river, by Mr. Fitzgerald, to your predecessor, in 1870, the estimated cost of improving two hundred and thirty-three miles of river, based upon the removal of 210,000 cubic yards of gravel, was \$180,000. When he made his examination, the river, I am told, was at a high stage and much of his information was collated from those who professed to know all about the stream; so that his report, otherwise an admirable one, was, in my opinion, greatly at fault as regards the quantity of material to be removed by dredging.

Experiment afterwards proved that dredging alone was of no benefit. There are, according to the report in question, about 125 shoals to be improved to admit of the free navigation of less than 250 miles of river. From present appearances, I should say that the cost of improving them will average not less than \$4,000 to each shoal, or not less than \$500,000 in all; and this, if done upon the present plan, will require frequent retouching. The cost of locking and damming would be enormous.

The present commerce of the river amounts to almost nothing, although the people interested claim that it will increase if the Government opens the river. But if the value and extent of the commerce should rise to the figure they claim it will upon the river being improved, an average depth of 2 feet of water would not, in my opinion, suffice, and slack-water would then be called for.

These remarks may appear superfluous in an inspection report, yet I should fail in my duty to my Government should I neglect to report the facts as they appear to me. Having accomplished my inspection, I returned to St. Louis on the evening of the 10th.

Very respectfully, your obedient servant,

CHARLES J. ALLEN,
Captain of Engineers, U. S. A.

Col. J. H. SIMPSON,
Corps of Engineers, U. S. A.

APPENDIX L.

ANNUAL REPORT OF CAPTAIN W. H. H. BENYAURD, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1874.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., July 1, 1874.

GENERAL: I have the honor to submit the following reports of progress made in the works under my charge for the fiscal year ending June 30, 1874.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

L 1.

IMPROVEMENT OF THE OUACHITA RIVER, LOUISIANA AND ARKANSAS.

In accordance with instructions from the Chief of Engineers, the crane-boat Ouachita was refitted and repaired at Camden, Ark., and commenced work on the 25th of August upon the removal of the most dangerous obstructions to the safe navigation of the river. On account

of the frequent rises in the river the operations were very much delayed and interfered with, so much so that the amount of work performed was small compared to the length of time that the boat was in commission. The report of Mr. Justin Straszer, assistant engineer, is annexed hereto. It will be seen, by reference thereto, the disadvantages under which the work is carried on, when working with a boat like the Ouachita, which is devoid of self-propelling machinery, and shows the necessity of having a light-draught steamboat for the Ouachita and its tributaries.

A recommendation to this effect is made in my report upon the survey and plan of improvement of the river.

A resurvey of the river from Camden, Ark., to Trinity, La., a distance of two hundred and ninety-five miles, was made during the summer and fall of last year. The report thereon was forwarded to the Department on the 12th of May last, and printed in Ex. Doc. No. 259, H. R., Forty-third Congress, first session. A copy is appended hereto. This report contained a recommendation in regard to a snag-boat, as mentioned before. It is particularly desirable that one be built, and the amounts asked for in the financial statement below are for the running expenses of that boat for one season.

The contemplated improvement, by locks and dams, called for certain amounts of lumber for the foundations of locks at Buffalo Flats and Jack's Island, in Arkansas, and at Rock Row in Louisiana. At the beginning of the last fiscal year the contracts were under way for the delivery of the various amounts required, the time of completion of the contracts having been extended until the 15th of August. At that time the contractor, finding that he could not complete the delivery without a further extension until the following season, gave up his contract. About two-thirds of the material had been delivered, at a cost of \$20,708.52. It is stacked at Buffalo Flats and Eldorado Landing, Ark., and protected as well as circumstances would allow. Should the material not be required for the improvement of the river, an early sale would be advantageous, in consequence of the liability to decay and the expense of taking care of it.

During the coming season it is proposed, if the recommendation in regard to the snag-boat be approved, to build one, and operate it in removing the obstructions from the river.

Financial statement.

APPLIED TO LOUISIANA.

Balance in Treasury of United States July 1, 1873.....	\$81,000 00
Amount in hands of officer and subject to his check.....	11,254 07
Amount expended during the fiscal year ending June 30, 1874.....	30,755 15
Amount available July 1, 1874.....	61,498 92
Amount required for the fiscal year ending June 30, 1876.....	13,000 00

APPLIED TO ARKANSAS.

Balance in Treasury of United States July 1, 1873.....	35,000 00
Amount in hands of officer and subject to his check, (including \$460.50 percentage due on contracts not yet completed).....	13,573 05
Amount expended during the fiscal year ending June 30, 1874.....	30,486 49
Amount available July 1, 1874.....	18,086 56
Amount required for the fiscal year ending June 30, 1876.....	13,000 00

Report of Mr. Justin Strdszer, Assistant Engineer.

VICKSBURG, MISS., December 9, 1873.

SIR: In compliance with your orders dated November 27, 1873, the field operations in removing obstructions to navigation in Ouachita River in the States of Arkansas and Louisiana were suspended on receipt of said orders.

Having been assigned by you to the command of the United States crane-boat Ouachita, engaged in the said operations, I now have the honor to present to you my report for the season.

After having completed the necessary repairs at Camden, Ark., I left that port with the crane-boat on the 25th of August. According to your instructions, the work was to be confined to the removal of the principal obstructions on the shoals, and such in the pools as were deemed absolutely necessary.

For that purpose one of the oldest and best pilots of Ouachita River was employed to point out for removal those obstructions which he considered as the worst in the river and impeding navigation, especially at low water.

There was also employed a force of laborers to cut up all the trees lying on the slopes of the banks, which trees had either caved in or were cut down during the previous season by the United States dredge-boat Octavia; but as the stage of the river was then too high when the latter was at work, they could not be cut up at the time into short pieces, and remained, therefore, lying where they were felled.

On the 2d day of October the crane-boat had reached Bangs's Landing, five miles below Champagnolle, when the above work was brought to a close by a big rise in the river; extraordinary, not only for that season of the year, but also for its height and duration.

Governed by several reasons, which I submitted to you in my special report at the time, I floated the crane-boat down stream to Monroe, La., and after the rise in the river had so far subsided so that operations could be resumed, I engaged in removing the obstructions lying in front of the wharf-boat at Monroe.

These obstructions consisted of the piling of the foundation of the bridge-piers and a mass of timbers which formed part of the turn-table of the railroad-bridge, which was burned during the late war and had fallen into the river.

At this particular kind of work I succeeded in removing a large number of the said timbers, and pulled out also the two lowest piles. All further attempts, however, to pull the rest of the piles proved useless, and I did not dare to apply greater power without risking the existence of the crane-boat.

Not having any machinery for sawing under water, nor any apparatus for blasting, I was obliged to abandon all further work on that object for the present season. Although there are many logs on several of the shoal places and bends below Monroe, no work could be done toward the removal of the same, partly on account of their being covered by water in such a depth that it was impossible to get any hold on them, and again, on account of the low temperature of the water, which prevented the men from working in it, which was the only way possible and usually employed to attach the lines or chains of the hoisting apparatus to these obstructions.

The next principal obstruction, where the stage of water did not interfere at the time with work, was the wreck of the steamboat Henry Homeyer, twenty-three miles below Monroe. While, however, engaged in removing this obstruction, another rise in the river, coming out principally of Bayou D'Arbonne and Bayou Cheniere, retarded the progress of the work considerably, losing much time by bad weather and high winds.

Those parts of the wreck which formed the principal obstruction to navigation were removed entirely.

The wreck of the steamboat Dr. Batey was the next object of work, but already, after three days of work, the river again commenced to rise so rapidly that it became impossible to achieve further results. As the rains at the time were general throughout Arkansas and Louisiana, swelling all the feeders and tributaries of Ouachita River, there was no probability that the river would fall again to a stage at which work could be done with advantage, more so as the season was far advanced, and rainy weather expected to keep the river up to a good boating stage.

In view of these facts, I received your orders to suspend operations, and lay the crane-boat up at Monroe, La.

The following comprises the work performed by the United States crane-boat Ouachita during the season:

Number of snags destroyed and removed from the channel, 153; number of trees cut up into short pieces, 10,074. This work was accomplished in thirty-three working-days during the latter part of August and month of September, from Camden to Bangs's Landing, representing a distance of fifty-six miles.

The work performed during the months of October and November consisted of removal of railroad turn-table opposite the wharf-boat at Monroe, La.

Removal of the principal parts of the wreck of the steamboat Henry Homeyer.

The removal of parts of the wreck of the steamboat Dr. Batey cannot be regarded as improving navigation, as the work on that object was suspended on the third day.

The time employed on the above objects of work is divided as follows: Railroad turn-table, 6 working-days; wreck of Henry Homeyer, 12 working-days; wreck of Dr. Batey, 3 working-days.

Twenty working-days during the months of October and November were lost by either high water, rainy weather, or high wind, while the balance of the time, excluding Sundays, was consumed in running from Bangs's Landing, Ark., to Cuba, La., a distance of one hundred and forty-four miles.

In comparing the above figures of the work accomplished, time employed, and the distance run over, it appears that the comparison is not much in favor of the quantity of work performed during the season. It is also apparent that much time was lost by either running or laying up on account of high water at certain localities. That no better results were obtained lies principally in the fact that the crane-boat Ouachita is devoid of self-propelling power. As her equipments are only such as to float her down-stream to reach the different objects of work, even a small rise of from 3 to 4 feet in the river is sufficient to cover up most of the obstructions, and the party is then obliged to stop work and wait until the rise has run out. Much valuable time is thereby lost, while the expenses are going on at the same rate, and when such a rise assumes dimensions, as was the case in every instance during this last season, then the time lost in awaiting the decline of the river at a certain locality is almost equal to the time employed by actual work; consequently the disadvantage of having no propelling power is so much more apparent. During such delays officers and crew have to be kept in employ, because if discharged it would be difficult to get up a crew when required, especially if such an occurrence should take place in the region known as the "overflow," in the thinly-settled parts of the country, or at a time when most of the laborers are employed for agricultural purposes.

If again, in case of such a rise, the movement of the boat down stream is continued, then that part of the river, with all its obstructions, inaccessible at the time, is neglected, and there is no possible chance to return during the same season to these places which have been passed over, and where, nevertheless, work is very much needed.

These facts clearly demonstrate that, in order to accomplish good work, in relation to the time employed and the great distance over which the work extends, it is absolutely necessary to have a boat which has better facilities for moving about than being propelled by hand-power, and for that purpose I respectfully recommend the building of a light-draught stern-wheel boat, equipped with hoisting-apparatus, and all such machinery, whereby steam can be substituted for hand-labor without injuring her capacity as a light-draught boat.

Such a boat would be of immense benefit in removing the obstructions to navigation in Ouachita River, self-propelling power rendering her independent of the sudden changes in the stage of the river. She could be put at work whenever the stage of the river is most favorable to do the work good, while a flat-boat can only work during the summer and autumn. The stern-wheel boat can extend her operations for several months longer by governing her movements according to the rise and fall in the river.

The crane-boat Ouachita has been now in commission three seasons, and has by this time forfeited all claim to the character of a light-draught boat. The machinery is in good condition, while the hull of the boat requires a thorough overhauling and a great many repairs. These repairs cannot well be done at any other place than a regular ship-yard, the nearest of which is at New Orleans, La. The expense of repairs, with those of towing her to and from the nearest dock, can safely be estimated to be not less than building a new hull altogether, whereby, however, the other disadvantages which adhere to a boat without self-propelling power would not be remedied.

There is a large amount of work on Ouachita River which awaits immediate attention during the next low-water season, and, as prominent objects, might be mentioned the lower wrecks in the lower part of the river, and the obstructions formed by the piles of the old railroad-bridge at Monroe, La.

To achieve any good results in the shortest possible time, I earnestly recommend the building of a light-draught stern-wheel boat, with all the necessary equipments to enable her to equally remove snags, as also other obstructions in the river. To operate successfully, her outfit should comprise also a submarine armor, machinery for sawing under water, and a complete blasting-apparatus.

I am, major, very respectfully, your obedient servant,

JUSTIN STRASZER,
Assistant Engineer.

Maj. W. H. H. BENYAURD, U. S. A.,
Captain Corps of Engineers.

L 2.

SURVEY OF OUACHITA RIVER FROM CAMDEN, ARKANSAS, TO TRINITY LOUISIANA.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., May 12, 1874.

GENERAL: I have the honor to transmit herewith the report of Mr. C. W. Durham, assistant engineer, upon the survey of the Ouachita River from Camden, Ark., to Trinity, La. A survey had previously been made by Mr. Clement Smith, civil engineer, under direction of Lieut. Col. W. F. Reynolds, but it was deemed necessary to have a re-survey of the river made to determine more definitely certain questionable points connected with the contemplated improvement by locks and dams, which had been adopted, upon the results of the previous survey. This plan of improvement contemplated the building of five locks and dams, (timber,) located, respectively, at Catahoula Shoals, Taylor's Shoals, and Rock Row, in Louisiana; and at Jack's Island and Buffalo Flats, in Arkansas. The size of the above-mentioned locks was 49 by 250 feet, with an average lift of 14 feet. The estimated cost of the improvement was \$1,163,083.75.

I will here state that work has already been inaugurated by the delivery at Buffalo Flats and Eldorado Landing, Ark., of certain quantities of lumber intended for the foundations of the locks at Buffalo Flats, Jack's Island, and Rock Row.

In accordance with the report of the Board of Engineers convened by Colonel Simpson, a revision of the project for the improvement of the Ouachita River was directed by letter of June 6, 1873, from the Chief of Engineers. The errors and omissions as stated by the board in their report are correct; and, in addition, many others are found.

The distance from Camden to Trinity is 294.07 miles, with a total fall at low water of 64.5 feet, this being an average of .22 feet per mile. This fall is divided between two certain points, as follows:

Points.	Distance in miles.	Fall in feet.	Fall per mile.	Remarks.
Camden to Eldorado Landing	43.71	17.3	.396	Includes overflow region.
Eldorado Landing to Jack's Island	32.12	9.0	.280	
Jack's Island to Ouachita City	64.87	9.1	.140	
Ouachita City to Columbia	85.81	23.4	.273	
Columbia to Trinity	67.76	6.6	.097	

The river is a succession of pools and shoals. An inspection of the maps shows the existence of sixty-five of the latter, with a total length of about 40 miles, or nearly one-seventh of the entire length of that portion of the river under consideration, and the least depth on many of them is less than *one foot*.

The difference between extreme high and low water at Camden is 39.25 feet; at Trinity it is 53.4 feet. The low summer-discharge at Camden is 353 cubic feet per second. This small quantity of water, though amply sufficient for the plan adopted, is inadequate for any other means of improvement for the upper part of the river.

Humphreys and Abbot, quoting from Darby, in their report on the Mississippi River, say:

Few rivers differ more in the quantity of water at different seasons than the Ouachita; flowing from a hilly or mountainous tract, more constancy might be expected

in the column of water, but though the places drained by the Little Missouri and Fourche au Cado are not deficient in springs, yet the extensive region toward the sources of the Ouachita has little water except what is supplied by rains in winter and spring. When the parching heat of summer has dried the country above the mouth of the Little Missouri, the Ouachita becomes very low so far south as the head of Black River.

After an examination of the subject, I am satisfied that the plan of improvement by locks and dams is the only one that will give permanent and uninterrupted navigation to Camden, Ark., throughout the entire year. All others, whether by wing-dams or dredging, would be only temporary in their character. The project, as approved by the Department, requires revision on account of faulty location of dams, &c., and not being adapted to any but the very smallest boats navigating the Ouachita.

The steamers navigating the river may be divided into the two classes of side-wheel and stern-wheel boats. A list of these, and also the number of trips made by them to Camden during the season of 1872 and 1873, will be given further on, when the commerce of the river is considered. Of the above steamers the Ouachita Belle (side-wheel) and the Lotawanna, (stern-wheel,) being the largest in their respective classes, will be taken as the representatives thereof in considering the size of the locks adapted to them. The former is 67.5 feet wide out to out, 250 feet long, 8½ feet draught; the latter is 47 feet wide out to out, 180 feet long, and 6 feet draught. The contemplated locks being 49 feet wide, with 4 feet on lower miter-sill, it will be seen that none but the smallest stern-wheel boats would have the benefit of the improvement at the time it would be of service. With a stage of water a few feet above low water, without any improvement, the larger class could navigate the river with safety; but with the improvement, as adopted, they would be debarred unless the stage of water sufficed to allow them to go over the dams. These being fixed at about 19 feet on the average, it would require at least 9 feet on the combs of the dams, or a depth of 28 feet, to allow them to pass safely. The difference between extreme high and low water at Camden is, as before stated, 39.25 feet; at Monroe, 46.2 feet. We have not sufficient reliable data regarding the duration of a stage of water which will give the above depth of 28 feet at the different locations of the dams, but if we take the present season as an example, (for there has been an extraordinary amount of water in the Ouachita,) it would be at Camden about two months, and at Monroe about ten weeks. The principal objection to navigation over the dams is, that the river falls so rapidly at times as to endanger the boats being caught between them, and being too large for the locks, will have to await the return of high water.

A glance at the plots of the gauge-records will show the fluctuation to which the Ouachita is liable.

If it be desired, then, to accommodate the larger-sized boats, the following may be considered:

1st. Locks large enough to accommodate boats of the class of the Ouachita Belle the entire distance to Camden.

2d. Locks large enough to accommodate that class to Monroe, with smaller locks above for the other class, causing a transfer at Monroe; or, if we exclude the side-wheel steamers entirely from the use of the locks and increase their number, thus diminishing their lift, so as to give the larger steamers a longer time to navigate over the dams, we have—

3d. Locks sufficient only for stern-wheel boats. The locks will be 30

feet high, and will, therefore, be entirely submerged during the extreme high water, but their construction can be such as to prevent injury.

Under the first case, the following would be the location of the locks and dams, shown on profile in red; locks 70 feet in width by 300 feet between gates, 10-foot lift:

	Feet.
No. 1. Station 9,361, Louisiana, about two miles above Trinity, dam	700
No. 2. Station 5,893, Louisiana, about one mile above Columbia, dam	600
No. 3. Station 4,300, Louisiana, foot of Taylor's Shoals, dam	550
No. 4. Station 2,300, Louisiana, about one mile below Egg Point, dam	500(?)
No. 5. Station 4,940, Arkansas, about one-half mile below Belle Point, dam	350(?)
No. 6. Station 3,620, Arkansas, foot of Horse-head Shoals, dam	350(?)
No. 7. Station 1,280, Arkansas, foot of Newport Shoals, dam	350(?)

Dams Nos. 4, 5, 6, and 7 will have to be prolonged from 100 to 300 feet beyond the banks, and the pools created by them would partially flood the lands adjacent to the river.

The estimated cost of these seven locks and dams is: Masonry locks, \$4,952,976; timber, \$2,644,768.

Second case, dams Nos. 1, 2, and 3 would be located as above, the remainder as follows, with lifts of 8 feet, size 49 by 250 feet:

	Feet.
No. 4. Station 2,215, Louisiana, about foot of Egg Point Shoals, dam	450
No. 5. Station 264, Louisiana, about foot of Mallard Shoals, dam	400
No. 6. Station 3,921, Arkansas, near Jack's Island, dam	800
No. 7. Station 2,070, Arkansas, near Smackover Creek, dam	600
No. 8. Station 1,168, on Buffalo Flats, dam	500

Estimated cost of these eight locks and dams: Masonry locks, \$5,162,319; timber, \$2,626,252.

Third case, locks 49 by 250; lift, 7 feet:

	Feet.
No. 1. Station 8,698, Louisiana, near Harrisonburgh, dam	800
No. 2. Station 5,893, Louisiana, about one mile above Columbia, dam	600
No. 3. Station 4,851, Louisiana, Layton's Bar, dam	500
No. 4. Station 2,881, Louisiana, foot of Monroe Shoals, dam	600
No. 5. Station 2,215, Louisiana, Egg Point Shoals, dam	500
No. 6. Station 264, Louisiana, foot of Mallard Shoals, dam	400
No. 7. Station 4,160, Arkansas, Pine Prairie Shoals, dam	500
No. 8. Station 2,860, Arkansas, foot of Franklin Shoals, dam	400
No. 9. Station 1,280, Arkansas, foot of Newport Shoals, dam	300
No. 10. Station 975, Arkansas, foot of Spoon Camp Shoals, dam	400

Estimated cost of ten locks and dams: Masonry locks, \$6,079,233; timber, \$2,995,566.

It must be remembered that, in making these estimates, the cost is greatly increased on account of the character of the country in which the improvement is contemplated, as it offers no facilities for securing skilled labor, or material of any kind except timber, and requiring every other material that would be used in the construction of the works to be brought from a distance, and before navigation closed, thus greatly enhancing the cost, in addition to which any number of claims would be brought against the Government for damages supposed to be done to the lands on account of the pools created by the dams.

In each of the plans of improvement mentioned above, one of the locks will be located between Moro Bay and the mouth of Saline River, a distance of 32 miles. At moderate stages of water the Ouachita connects with the Saline through the old bed of Moro River, and in order to prevent the drainage of the upper pool, a dam will have to be built across the head of the old bed of Moro River.

In considering the above plans of improvement we must, from the beginning, take into account the floods of the river, and the damage to which

the works will be subjected by placing them in a channel so contracted as that of the Upper Ouachita, and upon soil so unstable as the river-bed.

So far as the permanent improvement of the river is concerned, that by locks and dams is the only one that will give continuous and uninterrupted navigation throughout the entire year to Camden, Ark.; and of the three plans mentioned above, the third, though it shuts out the larger class of boats, is the best, considering the nature of the river, the commerce, and the wants of the country, which the contemplated improvement will benefit.

In speaking of the improvement, and considering it, I have only introduced the Ouachita River. There is another element to be considered in the solution of the question, and that is the condition of the bar at the mouth of Red River. Mr. Durham refers to it in his report. The mouths of this river have been filling up for years, and though the lower one opened last fall, (the first time for twenty years,) it is supposed to be only temporary.

At low water boats drawing over two feet find it almost impossible to get over the obstruction and enter the river. So long as it exists it is useless to attempt the permanent improvement of the Ouachita. If the latter be undertaken, so must the improvement of the mouths of Red River. Whether the object to be accomplished, viz, the permanent improvement of the Ouachita to Camden, Ark., is commensurable with the expense, is a question which must be considered.

The improvement will be of advantage to the country in *partly* facilitating the shipment of the cotton-crop and the return of plantation and other supplies, the cost of the latter being greatly increased by reason of the planter and merchant being under the necessity of laying in a stock, during the boating season, sufficient to last until the next return of navigation.

Camden has always been the principal shipping and receiving point on the Upper Ouachita, and particularly for the counties of Ouachita, Bradley, Calhoun, Dallas, Hot Springs, Hempstead, Nevada, Clark, Pike, Saline, and Montgomery. To render navigation permanent to Camden was the principal consideration in the proposed improvement. It was the trade and commerce of the above counties that built up Camden, and made it so much of a commercial point for the country of which it is the center. Since the improvement of the river has been agitated, another element has been introduced into the country, which to a great extent reverses the channel of trade; I refer to the completion of the Cairo and Fulton Railroad. This road connects at Little Rock with roads running to Saint Louis and Memphis, and passes through the middle of the belt of counties above mentioned. The plantation and other supplies heretofore finding their way from the north and west to New Orleans, and thence up the Ouachita, the cost increased by reshipment and commission, now find their way directly to the above places, at rates sufficiently cheap, compared with river-rates, as to cause large consignments from the North and West, and in such quantities as may be required, thus avoiding the additional expense attendant upon laying in an entire season's stock. So much has the road affected Camden, that every effort is being made to have a connecting line with the above road, tapping it at Arkadelphia. That the fears of the decline of trade with New Orleans are not only felt on the Upper Ouachita, but also by the people of Upper Red River, (the interest being about the same in both cases,) is shown by the address of the merchants of Shreveport to the New Orleans Cotton Exchange. They say:

We are connected with a system of railroads leading to the Gulf ports in Texas, and we fear a successful competition will be waged to divert the produce and trade tributary to Red River to other markets than New Orleans; besides, the Cairo and Fulton Road will be completed in October,* tapping the heart of the Upper Red River trade, and threatening to carry to Saint Louis and Memphis the cotton of that rich valley.

The following table gives the number of steamers and the trips made by them during the season of 1872 and 1873 to Camden, Ark.; more frequent trips were made to Monroe and Trenton. It gives some idea of the trade of the river:

Name.	Class of boat.	No. of trips.	Between ports direct.
Ouachita Belle	Side-wheel..	2	New Orleans to Camden.
P. W. Strader	do	3	Do.
Mayflower	do	8	Do.
Lottawanna	Stern-wheel.	7	Do.
Fontenelle	do	7	Do.
Ruth	do	6	Do.
Sabine	do	8	Do.
Garry Owen	do	4	Do.
Bannock City	do	1	Do.
Bertha	do	9	Do.
Billy Collins	do	2	Do.
Ora	do	1	Do.
Leo	Side-wheel..	1	Saint Louis to Camden.
Mary McDonald	do	2	Do.
W. J. Lewis	do	1	Do.
Fannie Lewis	do	2	Do.
Alice	do	1	Do.
St. Luke	do	1	Do.
Mountaineer	do	1	Do.

Representing a total tonnage of about 8,500 tons.

The trade of the river during the present season, which is not yet closed, will show a great decrease in the number of boats, mainly due to the receipt of supplies, &c., via Cairo and Fulton Railroad.

* Since completed.

Shipment of cotton for the past three years.

	1870-'71.	1871-'72.	1872-'73.
September	1,373	333	899
October	2,498	480	1,283
November	5,603	4,612	1,334
December	15,002	7,413	4,013
January	23,965	32,063	22,769
February	43,300	27,314	32,843
March	34,800	11,602	21,351
April	13,818	9,988	12,380
May	7,185	1,658	4,976
June	1,521	961	1,174
July	1,619	136	346
August	774	174	376
Total	151,458	89,034	103,679

The above also includes the shipments from Black River.

It will be seen from the above that the greatest amount is shipped during the last months of winter and the first of spring. This always accords with the best stage of water, though there is generally in December a stage sufficient for navigation, but the main bulk of the cotton is not brought out to be shipped until later. Any system of locks and dams during this season would be superfluous; in fact, such an improvement as contemplated would be more of an obstruction in a river like the Ouachita at that time. It would only be during the late summer

and early fall months that the improvement would be of particular service. During these months no crops are being moved, and no particular trade is being carried on that would induce boats to run, even if there was sufficient water naturally at these seasons. One, or at the furthest two, of the small Ouachita River packets would be sufficient for the trade. The improvement, if made, will cost, according to the lowest estimate above presented, \$2,626,252, and this involves also the improvement of the mouth of Red River, for which no estimate can be presented; without the latter improvement the locks would remain idle at the time they are intended for use.

The same might be said of the temporary means of improvement by dredging, for though some of the bars and shoal places below Monroe are composed of gravel of sufficient size to resist the force of the current, and reasonably good results might be obtained by dredging, yet, if we attempted to maintain a channel deep enough for the large boats, the same obstruction would deter such boats from taking advantage of the improvement. No doubt such an improvement will tend to develop the resources of the country and encourage and increase the cultivation of land now lying idle, by cheapening transportation in competition with the railroad line that will soon be built in that country; still, I fail to see the necessity, at the present time, of so costly an improvement of the river by locks and dams, and in view of all the circumstances I would respectfully recommend for the present the abandonment of the project for lock-and-dam navigation of the Ouachita.

By reference to Mr. Durham's report it will be seen that there are a large number of logs, snags, and other obstructions in the river, which are dangerous at all stages of water. I would respectfully recommend that a boat be built for the purpose of operating on the river and its tributaries. Such a boat can be used also during high water in removing great quantities of drift-wood, which, coming down the river with every flood, lodge in the sharp bends, and, remaining there after the river falls, form serious obstructions. By operating at high water upon these it would greatly lighten the work during the low-water stage. The need of such a boat is very much felt, and it would be of invaluable service.

The estimated cost of a steamer for the purpose is \$30,000, and the estimated running expenses per month about \$2,200.

The balance of appropriations available May 1, 1874, was \$82,496.09; of which, for Louisiana, \$62,937.13; and for Arkansas, \$19,558.96.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Report of Mr. C. W. Durham, Assistant Engineer.

U. S. ENGINEER OFFICE,
Vicksburg, Miss., May 9, 1874.

CAPTAIN: I have the honor to present my report on the survey of Ouachita River from Camden, Ark., to Trinity, La., made under your directions during the summer and fall of 1873.

Accompanying this report are—

1. A profile of the river, plotted on continuous profile-paper, the horizontal sides of the squares into which the paper is divided representing 300 feet each and the vertical sides one foot.

Lines are given representing the high and low water slopes of the river, and the bed of the channel. This latter line, which was obtained from the reduced soundings, shows the highest points in a selected channel of 100 feet in width, (in some few cases in the upper river 60 to 80 feet,) which points indicate the maximum of obstruction. Also lines representing various systems of locks and dams.

2. A tracing of the map divided into 11 sheets. The map is plotted on a scale of 200 feet to 1 inch. The entire line of traverse and the transit points, as well as the soundings taken during the survey, are shown, together with the names of towns, landings, plantations, bayous, shoals, and bars, and as much general and topographical information as time and space permitted.

3. A sheet showing the curves of oscillation of water-surface at the different gauges during a portion of the years 1873 and 1874.

The party was organized at Camden, in June, and the survey was commenced at that point and carried on almost uninterruptedly until the 31st of December, at which time we had reached Trinity. A traverse-line was run throughout the entire distance, crossing from one bank to the other when found expedient for the purpose of avoiding natural obstructions, the opposite side being located by triangulation.

The stations begin at Camden with zero, were numbered from thence to the Arkansas and Louisiana State line, from whence, beginning again with zero, they were numbered to the terminus of the survey, thus affording an independent nomenclature for that portion of the survey in either State.

The heights of both banks were taken at frequent intervals, and the general topographical features of the country noted.

A line of levels was run, the elevation of the water-surface being taken as often as necessary; bench-marks were established, and frequent connections made with the levels of the survey of Mr. Clement Smith, (1871.) Numerous soundings were made, particular attention being paid to the shoal parts of the river-channel where future improvement may be found necessary. A water-gauge was kept at the quarter-boats, the records of which, together with those of the permanent gauges established at Camden, Buffalo Flats, Eldorado Landing, Monroe, Columbia, and Trinity, have been made use of in correcting the slopes of water-surface as obtained from the levels, as well as in establishing the line of low water.

The distance by river from Camden to Trinity, as found by our measurement, is 294.07 miles, and the total fall at low water is 65.4 foot, or .22 foot to the mile. The distance from Camden to the Arkansas and Louisiana State line is 114 miles. The extreme range of water-surface at Camden is 39.25 feet, while at Trinity it is 53.4 feet. The high-water slope is less than that at low water; a result mainly due to the back-water of the Mississippi in its high stages, which has at times, as I am informed, extended as far up the Ouachita as the State line. The extreme high water of the present season in the Lower Ouachita and Black, and the consequent disastrous overflow, are in great measure owing to the influence of the Mississippi.

The fall is distributed over a succession of pools and shoals, the former being almost invariably sufficiently deep for navigation, while some of the latter afford an available depth at low water of *less than a foot*.

A list of the shoals which form the chief obstructions, and which are very numerous the upper river, between Camden and Monroe, is given below.

In estimating the available depth at low water, allowance in width of selected channel has been made for the swing of boats in rounding the sharp bends and in crooked portions of the channel. The indicated depth on any given shoal is the least a steamer would be likely to meet with in passing at extreme low water.

Table of shoals from Camden, Ark., to the State line.

(MEM.—Figures in first and third columns are red in original.)

Name.	Distance from Camden.	Length.	Available depth at low water.	Remarks.
	Miles.	Feet.	Feet.	
Hodges	4.00	1,300	1.1	Gravel.
Two Bayou	5.50	4,000	2.4	Gravel and sand.
Little Buffalo	10.50	800	1.7	Gravel.
Cape Horn	11.00	500	0.6	Gravel; channel very narrow.
White Hall	12.25	500	1.9	Gravel and sand.
Frenchport	13.25	300	0.6	Gravel.
Cold Bite	17.50	500	0.8	Gravel; narrow channel.
Spoon Camp	18.00	2,200	0.7	Gravel.
Buffalo Flats	19.00	11,600	0.8	Gravel and sand; channel narrow and very crooked.

Table of shoals from Camden, Ark., to the State line—Continued.

Name.	Distance from Camden.	Length.	Available depth at low water.	Remarks.
	<i>Miles.</i>	<i>Feet.</i>	<i>Feet.</i>	
Newport.....	23.75	1,400	1.1	Gravel and sand.
Lower Newport.....	25.00	2,500	3.0	Do.
Ingleby.....	27.00	1,200	1.8	Do.
Hog Eye.....	30.75	1,000	1.5	Do.
Haidee.....	36.00	2,900	1.0	Do.
Slim Island.....	36.75	3,600	1.0	Do.
Sackover.....	39.00	400	0.9	Gravel-bar; channel very crooked; swift current.
El Dorado.....	43.75	400	2.4	Sand.
Enterprise.....	48.25	4,000	1.8	Crooked channel; swift current.
Franklin.....	52.00	13,500	0.7	Series of shoals, with pools between; gravel; channel narrow and near bank.
Romeo.....	68.00	1,600	0.7	Gravel; crooked channel.
Horsehead.....	68.25	1,500	1.1	Sand; snags.
Caryville.....	71.00	1,500	0.6	Soft rock; channel very crooked.
Jack's Island.....	75.00	10,600	0.7	Series of sand-bars; snags; channel very crooked and narrow.
Line Prairie.....	78.75	2,600	0.9	Gravel and sand.
Farrigethe.....	82.67	2,500	0.7	Gravel and sand; channel very crooked and narrow, and full of logs and snags.
Entaw Rapids.....	83.50	2,000	1.4	Sand.
Caney Mary.....	88.00	8,000	0.6	Do.
No name.....	90.00	16,500	0.5	Series of sand-bars; channel very narrow.
Beland's Ford.....	111.00	8,400	1.1	Sand.

Table of shoals from State line to Trinity, La.

Name.	Distance from State line.	Length.	Available depth.	Remarks.
	<i>Miles.</i>	<i>Feet.</i>	<i>Feet.</i>	
Shiloh.....	3.50	3,400	0.6	Gravel; narrow channel.
Mallard.....	4.50	1,000	1.1	Sand.
Thirteen Point.....	10.00	1,300	3.1	Do.
Alabama.....	12.00	300	0.9	Do.
Chignon du Chien.....	12.25	1,900	1.9	Do.
Fish Trap.....	13.75	1,500	1.7	Gravel and sand.
High Tower.....	19.25	3,200	1.6	Do.
Onachita City.....	26.50	400	1.4	Gravel-bar.
Young's.....	31.50	500	1.1	Gravel and sand.
Loch Lomond.....	32.50	2,400	1.0	Rock and gravel; narrow channel.
Rock Row.....	36.00	3,100	1.1	Rock; swift current.
Willow Island.....	40.50	3,700	1.1	Sand.
Keg Point.....	41.25	6,700	1.4	Do.
Doddy's.....	46.25	4,300	1.8	Do.
D'Aubonne.....	47.50	1,500	2.1	Sand and gravel.
Two Paw.....	50.00	1,500	2.0	Sand.
Momroe.....	53.00	14,000	2.2	Series of sand and gravel-bars.
Dim & Gravel's.....	60.00	700	2.4	Gravel.
Chesier Bar.....	67.00	2,300	2.9	Sand and gravel.
Momison's.....	70.00	4,300	2.5	Do.
Thom Knob.....	71.00	400	2.5	Gravel.
Rock Island.....	71.50	1,100	1.4	Rock and gravel.
Philips.....	72.00	500	1.4	Sand.
Tanner's Bar.....	73.25	6,300	0.7	Sand; channel very narrow.
Logtown.....	75.25	1,700	0.9	Sand and gravel.
Taylor's.....	77.50	11,700	0.9	Series of gravel-bars; crooked channel.
Bark's.....	80.25	800	2.9	Sand.
Faulk's.....	81.50	800	3.0	Do.
Bell's.....	82.00	1,400	2.9	Do.
Cypress Bayou.....	87.25	600	2.6	Do.
Layton's.....	91.75	500	2.2	Do.
Hopewell's.....	93.25	100	2.7	Do.
Wall's.....	94.50	100	3.0	Do.
Reidland's Bar.....	100.00	5,800	1.1	Gravel and sand.
Catahoula.....	160.00	7,500	0.9	Gravel and sand; current very swift; channel very narrow and crooked.
Louis Bayou Bar.....	162.00	4,500	3.3	Series of sand-bars.

The velocity of the current on the different shoals varies at low water from 1.5 to 3 miles per hour, but in times of flood it is often much greater.

It will be seen by reference to the profile of the river and the list of shoals that ordinary methods of improvement, such as by dredging and rock-excavation or wing-dams, would involve enormous expense, even if practicable.

A series of careful observations of floats of mid-depths shows the amount of water passing at Camden at low water to be about 353 cubic feet per second, which amount, though ample for the contemplated system of locks and dams, would be insufficient for any other exhaustive method of improvement of the upper river. The course of the river is extremely crooked, and a large number of the bends are very sharp. The width of the main channel ranges from 45 to 400 feet. The net-work of bayous and lakes in which the Ouachita country abounds, acts as a natural reservoir for the water in times of flood, thereby allowing the river to have a more contracted waste-way than would otherwise be the case.

The chief source of danger to the navigation of the upper river, at *navigable stages*, arises from snags. A great part of these is the result of former ineffectual attempts to improve navigation by cutting down overhanging trees, or trees near the edge of the bank, sufficient precautions not having been taken to remove them; carried for a distance by a rise of water, they have been left as the water receded, on the shoals, where, becoming water-logged and imbedded in sand, they still remain.

They are the most numerous and dangerous at the following localities:

Distance from Camden, miles.

- 7½, Yeager's Tow-head.
- 18 to 22, above and on Buffalo Flats.
- 24, near Newport.
- 27, Ingleby Shoals.
- 33½, Leopard's Camp.
- 36, Haidee Shoals.
- 41 to 45, above and below Eldorado Landing.
- 48, Enterprise Shoals.
- 52, Franklin Shoals.
- 60, near Wilmington.
- 60 to 65, from Wilmington to Jack's Island.
- 88, near Cany Mary Landing.
- 93 to 140, from Belle Point to Ouachita City.
- 146, Loch Lomond Shoals.
- 149, Rock Row.

Much work was done under your directions by the crane-boat *Ouachita*, during the fall of 1873, in removing snags and logs from the channel between Camden and Wilmington, but, owing to high water, no snagging of any importance was done below. On the lower river, between Monroe and Trinity, there are also many isolated snags and sawyers, the removal of which would be very beneficial.

Another source of obstruction is in the leaning trees on the river-banks, the greater portion of which has been removed in previous operations, but considerable more work is necessary. The high-water channel hugs the bank very closely, especially at the bends, and a passing steamer runs great risk of losing her upper works at points where overhanging trees exist.

On the upper part of the river, between Camden and Ouachita City, one or both banks of the river are invariably low, and a large portion of the adjacent country is annually overflowed. The high lines strike the river only at a few points, and there is but little land on the river under cultivation, most of the farms being situated at a distance and above or near high-water mark. Between Caryville and Alabama Landing, a distance of 56 miles, both banks are submerged at even moderate stages, and vast tracts of bottom-land, covered with forest and canebrake, are under water five or six months in the year. On the lower river, between Ouachita City and Trinity, the banks are generally high and the country near the river is tolerably well settled, although not cultivated to so great an extent as formerly, the reasons for which are not to be found in imperfect navigation, but await the solution of the labor question. There is sufficient depth of water for the use of the greater number of the boats to Camden during seven months, and to Monroe from nine to ten months in the year. During the season of 1873 navigation to Monroe was closed only about six weeks.

The season of high water in the Ouachita is also the cotton-shipping season, during which some of the large Mississippi boats, together with those employed exclusively in the Ouachita trade, run upon the river, and long before it falls to its lower stages the cotton is almost entirely removed. At the same time supplies are brought to the planters and merchants resident upon and near the river, which supplies must also be made to cover the time during which the river is closed to navigation, a source of great inconvenience and distress, and the main argument in favor of continuous navigation.

On the 23d of November, 1873, with the water only 2½ feet above extreme low water, nearly all the boats which run the river were plying between New Orleans and Ouachita City, and carrying down cargoes of cotton. So soon as the cotton-crop is exhausted the boats cease running, or only a few at infrequent intervals, and this not always from lack of water, but from lack of trade; and it is difficult to see how, in the event of the establishment of slack-water navigation, this business would be adequately increased. As regards the present cost of shipping cotton via the Ouachita to New Orleans, it is but little, if any, greater than for equal distances on the Mississippi and Red Rivers, and during the season in which the cotton should be shipped there are ample facilities for doing so.

Monroe, in addition to its river connections, has a railroad, (Northern Louisiana and Texas,) which runs to Delta, a point on the Mississippi nearly opposite Vicksburg. The greater portion of the cotton raised in this section of the country goes out by this route. Navigation during the entire year can be secured to this point and Trenton, two miles above, at comparatively small cost, as will be seen from estimates below submitted. There is a railroad under construction from Arkadelphia to Camden, tapping the Cairo and Fulton Railroad, which runs to Little Rock, thence connecting with Memphis and Saint Louis. By this route Camden and the up-river country can receive supplies quite as cheaply as by boat, and if necessary cotton can be shipped.

Points above, and as far as Champagnolle, are easily reached by land, and can receive their supplies from Camden when navigation is closed. In the same manner Ouachita City and intermediate points can receive their necessities from Monroe.

Between Ouachita City, then, and Champagnolle, a distance of ninety-five miles by the river and about sixty by land, is the country which would be especially and chiefly benefited by carrying into effect the proposed project for slack-water navigation. There follows a list of the counties and parishes the interests and welfare of which are directly or indirectly connected with the navigation of the river. In the second column is given the population according to the census of 1870. The third column shows the assessed valuation of estate, real and personal, and the fourth exhibits the cotton-crop of 1870.

Counties and parishes.	Population.	Assessed valuation of real and personal property.	Cotton-crop of 1870.
			<i>Bales.</i>
Ouachita, Ark.	12, 975	\$2, 904, 387	6, 467
Calhoun, Ark.	3, 853	459, 193	2, 593
Bradley, Ark.	8, 646	1, 197, 458	5, 177
Union, Ark.	10, 571	1, 934, 123	6, 181
Ashley, Ark.	8, 042	1, 607, 906	7, 856
Union, La.	11, 685	1, 257, 911	6, 675
Morehouse, La.	9, 387	1, 986, 759	11, 154
Ouachita, La.	11, 582	3, 511, 160	14, 239
Richland, La.	5, 110	852, 574	6, 051
Caldwell, La.	4, 820	651, 087	4, 157
Franklin, La.	5, 078	588, 358	3, 498
Catahoula, La.	8, 475	1, 233, 563	8, 872
Total	100, 224	17, 484, 587	82, 930

Eighty-two thousand nine hundred and twenty bales, at \$40 per bale, which is a fair average value, would give \$3,316,800 as the valuation of the entire crop.

It has been before remarked that the benefit to be derived from the slack-water project, or from any improvement intended to furnish continuous navigation, would be in bringing supplies during the summer months. Putting the up-river freight at a value of say two-thirds that of the cotton, which is sufficiently high, we have as a total valuation of up-river freight \$2,211,200; only a part of this, say five-twelfths, corresponding to that portion of the year in which navigation is more or less impeded, is to be taken into consideration, and we have the result \$921,333. Should, however, the river below Monroe be improved, as below suggested and estimated for, there would remain only those counties and parts of counties on the river between Champagnolle and Ouachita City which would be greatly benefited by the improvement of the upper river. Camden, with its railroad, will have ample facilities for supplying itself and vicinity, and portions of the country have easy access to the Mississippi River. To furnish supplies during four or five months in the year to this section appears to be the ultimate and principal object of such improvement. That the expense would be immeasurably out of proportion to the results to be obtained may be seen from the following table. It shows the names of the counties or parts of counties included in the section above re-

ferred to, their population, valuation, and average cotton-crop, according to census of 1870.

Counties and parishes.	Popu-lation.	Valuation.	Average cot-ton-crop.	Remarks.
			<i>Bales.</i>	
Calhoun, Ark.....	964	\$114,800	648	About one-fourth.
Bradley, Ark.....	8,646	1,197,458	5,177	
Union, Ark.....	10,571	1,934,122	6,181	
Ashley, Ark.....	8,042	1,607,966	7,856	About two-thirds.
Union, La.....	7,790	838,608	4,450	
Morehouse, La.....	6,258	1,324,526	7,436	
Total.....	42,271	7,017,500	31,748	

Thirty-one thousand seven hundred and forty-eight bales, at \$40 a bale, would give \$1,269,920. Estimating value of supplies at two-thirds, we have \$846,613. Taking five-twelfths of this as the average for the five months in which navigation is impeded we have \$352,755. A single boat of average size could, if it were possible to run, meet all the demands. Owners of steamboats and others interested in the profits of navigation are dissatisfied with the project for slack-water, and call only for such measures as will render present navigation as free from danger as possible.

In regard to the survey of 1871, made by Mr. Clement Smith, a Board of Engineers has passed upon it, and numerous errors were found, the existence of which is confirmed by the present survey, and, moreover, additional ones have been discovered, more than sufficient, in my opinion, to warrant a condemnation of the project recommended.

I have made special examinations of those points at which locks are proposed to be constructed, or at least of the vicinity, no clew being given in the maps, notes, or report by which these sites could be exactly located. I have found them in every case defective. Insufficient soundings were made for determining the profile of the river-bed, and several shoals were neglected, some of which have an important bearing upon the result.

Numerous errors have been found in the levels of 1871, which have doubtless led to the greater part of the faults discovered.

The locks proposed are not of sufficient size to accommodate the larger boats, and new ones would have to be built, which would doubtless cause much dissatisfaction among present owners. During the cotton-shipping season some of the large Mississippi steamers use the river and carry the major part of the freight. Dams of the height proposed would practically bar them out of the river, or at least allow them to pass over only about two months in the year; and, aside from this drawback, it seems that wooden structures would hardly be secure, built to such a height in a very contracted water-way, completely surrounded and submerged at high water, as most of those proposed would be, and with no sufficient bank to offer security to the roots of the dams.

It is not believed that the pools made by the proposed dams would cause any real damage to the adjacent country, or that the prolongation of the high stages would be in any way detrimental, although claims for suppositions damages might arise. The high-freshet line varies from 39.25 feet above low water at Camden to 53.4 at Trinity, while the ordinary high water ranges from 30 to 40 feet, and is prolonged for some months, so that no land much below these limits could be cultivated, unless protected by levees. A system of ten locks and dams, with lifts of 7 feet, would better fulfill the conditions of security, and would not bar the large steamers for so great a length of time.

PLAN OF IMPROVEMENT.

In view of what has been above said, I would respectfully recommend the following project for improvement, which, although partial, will afford great relief:

1st. The construction of a light-draught steamboat, fitted with the requisite machinery for removing snags, sunken logs, &c., to work between Camden and Trinity, but principally above Monroe, La.

The cost of such a boat as estimated from plans in your possession would be about.....	\$30,000
The cost of running per year as obtained from comparison of precedents on this and other rivers.....	26,400
Total.....	56,400

Such a boat would be of the utmost service to navigation in removing the chief sources of danger, and could be made effective during the entire year.

2d. The widening and deepening of the channel between Monroe and Trinity by dredging and rock-excavation, so as to give at least 4 feet of water with 100 feet width of channel during the entire year.

This width and depth will be ample for such craft as trade would justify in using the river during the low stages.

The following list shows the names of shoals, their situation, and the quantity of work required in that portion of the river the improvement of which is here proposed. Some of them are built on a nucleus of snags and sunken logs, which being removed, the causes of obstruction would be eliminated. These shoals have been plotted, and the results were obtained by calculation from the soundings made during the survey.

They are presented as approximate, but are believed to be very near the truth.

Name of shoal.	Location—Louisiana.	Quantities in cubic yards.		Remarks.
		Rock.	Sand and gravel.	
Monroe	Station 2738 to Station 2878		15, 375	Including estimate for channel 200 feet in width, through a space extending 300 feet above and below wharf boat, to allow room for turning.
Dinkgrave's	Station 3902 to Station 3909		248	Gravel.
Bayou Chaniere Bar	Station 3533 to Station 3555		3, 849	Including some very soft rock.
Morrison's	Station 3653 to Station 3695		2, 944	
The Knob	Station 3743 to Station 3747		618	
Rock Island Rapide	Station 3767 to Station 3778	3, 413	4, 732	Rock soft and friable.
Philpot Landing	Station 3891 to Station 3896		3, 111	Sand.
Tanner's Bar	Station 3858 to Station 3990		30, 940	Sand.
Logtown	Station 3978 to Station 3995		17, 155	
Lytor's	Station 4083 to Station 4900		22, 140	
Reak's	Station 4241 to Station 4249		444	Sand.
Faulk's	Station 4295 to Station 4303		695	Sand.
Bell's	Station 4337 to Station 4351		1, 189	Sand.
Cypress Bayou	Station 4606 to Station 4612		368	Gravel.
Lytor's	Station 4646 to Station 4651		177	Sand.
Hopewell's	Station 4925		194	Sand.
Wells's	Station 4967		100	Sand.
Ratland's Bar	Station 5314 to Station 5372		565	Sand.
Catahoula	Station 8429 to Station 8504		14, 680	
Louis Bayou Bar	Station 8540 to Station 8585		661	Sand.
Total .....	.....	3, 413	119, 955	

As the work is not of more than ordinary difficulty, I have estimated the rate per cubic yard for sand and gravel at 35 cents and for rock \$2, which will give—

119,955 cubic yards of sand and gravel, at 35 cents. \$41, 984 25
 3,413 cubic yards of rock, at \$2 6, 826 00

48, 810 25

Add 15 per cent. for contingencies 7, 321 54

Total 56, 131 79

I have to state that there would be no guarantee for the permanence of the above work, inasmuch as the factors of danger are the same as for other rivers of this class, rivers of average rapidity of current, crooked, and with unstable bottoms of mud, sand, and gravel. Should, however, the work be determined upon, I would respectfully recommend that it be done by contract, as being cheaper and more expeditious in view of the comparatively small quantities, as not justifying the necessary outlay for machinery, &c., on the part of the Government.

I have now to call your attention to the bars at the mouth of Red River, which I have not personally examined, but which I learn from various sources give but 18 inches at low water. They have, therefore, an important bearing upon any improvement intended to furnish low-water navigation on the Ouachita, inasmuch as its only outlet to the Mississippi is via Black and Red Rivers and over these bars. An examination of this locality seems imperatively needed, and its improvement would be of the utmost importance to the navigation of the Red, Black, and Ouachita Rivers. Some improvement of the principal tributaries of the Ouachita, viz: Bayous Moro, Bartholomew, and d'Arbonne, Boeuf and Saline Rivers, would be beneficial to the country concerned.

In conclusion, I beg to acknowledge my appreciation of the able services of Assistants Mack, Gordon, and Nicol, both in field and office.

Very respectfully, your obedient servant,

C. W. DURHAM,
Assistant Engineer.

Capt. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

L 3.

IMPROVEMENT OF THE YAZOO RIVER, MISSISSIPPI.

An appropriation of \$40,000 for this river was made by act of Congress approved March 3, 1873.

Upon the project for the improvement being approved by the Chief of Engineers, proposals were solicited for the removal of certain wrecks.

The following is an abstract of bids received for removing nine wrecks from the Yazoo River, Miss.

Number.	Names and residence of bidders.	Names and residence of guarantors.	By whom certified.	Arcadia.	R. J. Tachland.	Golden Age.
				1	2	3
1 {	Underwriters' Wrecking Co., Cincinnati, Ohio.	M. A. Bryson, St. Louis, Mo. J. M. Mason, St. Louis, Mo.	E. W. Fox, surveyor and acting collector.	\$5,000	\$7,000	\$5,000
2 {	G. Andrews, president New Orleans Wrecking and Salvage Co., New Orleans, La.	Edward A. Yorke, New Orleans, La. W. J. J. Armstrong, New Orleans, La.	J. R. Beckwith, United States attorney.	4,800 4,850	4,500 5,000	4,000 4,500

Number.	Names and residences of bidders.	Glyde.	Petrel.	Ivy.	Van Dorn.	Polk.	Idaho.	Totals.	Remarks.
		4	5	6	7	8	9		
1 {	Underwriters' Wrecking Co., Cincinnati, Ohio.	\$5,000	\$3,000	\$3,000	\$5,000	\$4,000	\$3,200	\$40,200	
2 {	G. Andrews, president New Orleans Wrecking and Salvage Co., New Orleans, La.	3,800	3,800	3,900	3,900	4,200	2,550	35,450	(a) Parts of value to belong to contractor.
		3,950	3,850	3,950	4,450	4,450	3,000	38,000	(b) Parts of value to belong to Government.

The award was made to Mr. G. Andrews, president of the New Orleans Wrecking and Salvage Company, the lowest bidder. A contract was thereupon entered into, the work to be commenced September 1, 1873, and finished February 1, 1874. The contractor commenced work upon the day specified, and completed his work in a very satisfactory manner January 17, 1874.

Mr. Joseph Burney, assistant engineer, superintended the removal of the wrecks, and also made an examination of the river, to determine more definitely the location of the remaining wrecks and other obstructions to the safe navigation of the stream. His report is annexed hereto.

It will be seen that there are eleven wrecks remaining, forming obstructions, and in addition, many beds of sunken logs, which are, by far, the more serious of the two, besides overhanging trees that require to be cut down. Mr. Burney estimates that \$120,000, extending over a period of four years, will be sufficient for the improvement of the river, by the removal of the above-mentioned obstructions. Experience gained last season in the removal of the wrecks by contract shows that the removal of the remainder, and also the removal of the sunken logs, could be done at much less expense by the Government owning and controlling its own boat than by letting the improvement out by contract. An appropriation of \$75,000 could be advantageously expended in building a suitable boat and operating it for parts of two seasons. As no appropriation was made for the fiscal year ending June 30, 1875, and as the balance remaining on hand is very small, no work can be done during the present season.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$35,000 00
Amount in hands of officer and subject to his check.....	5,000 00
Amount expended during the fiscal year ending June 30, 1874.....	39,023 06
Amount available July 1, 1874.....	976 94
Amount required for the fiscal year ending June 30, 1876.....	75,000 00

Report of Mr. Joseph Burney, Assistant Engineer.

VICKSBURG, MISS., June 29, 1874.

MAJOR: I have the honor to report that, in accordance with your instructions, I have made a careful examination of the Yazoo River, with a view to its improvement.

The Yazoo River is formed by the junction of the Tallahatchie and Yallahusha Rivers, three miles above the city of Greenwood, and runs, according to the township-maps, through the State of Mississippi to its junction with the Mississippi River, twelve miles above Vicksburg, a distance of one hundred and seventy-three miles. There are four classes of obstructions to navigation in the Yazoo River, viz:

- 1st. Sand-bars.
- 2d. Wrecks.
- 3d. Snags.
- 4th. Overhanging trees.

The bar forming the greatest obstruction is at the mouth of the river, and is of a very changeable nature; the location of the channel being often changed, but, as steamboats drawing 2 feet of water can pass at extreme low water, and those boats being sufficient for the business required at this season of the year, I submit no estimate for its improvement.

The second class of obstructions are the wrecks of steamboats sunk during the late war. Under your direction, last year nine wrecks were removed, which greatly improved the navigation of the river. There are eighteen wrecks yet remaining in the river; of these, seven form no obstruction, the remaining eleven are, to a certain extent, in the way of navigation, and any plan adopted for the thorough improvement of the river would require them to be removed.

Below I give a list of the wrecks, also an estimate for the removal of those in the way of navigation.

Wrecks forming no obstruction.

Name.	Location.
Fall City.....	Near Snyder's Bluff.
Cairo.....	Six miles above Chickasaw Bayou.
Republic.....	One mile below Yazoo City.
J. F. Pargond.....	Half mile above Yazoo City.
Prince of Wales.....	Opposite Andrews' Landing.
John Walsh.....	Opposite Southworth's Landing.
Scotland.....	Do.

Wrecks forming obstruction.

Name.	Location.	Estimate. Cost of removing.
Paul Pry	Two miles above mouth of Big Sunflower River	\$3,000 00
Capitol	Half mile below Liverpool Landing	4,000 00
Hope	Eagle Bend	3,000 00
Baron De Kalb	Two miles below Yazoo City	3,500 00
Mobile	do	3,000 00
Magenta	Four miles above Yazoo City	4,000 00
Magnolia	do	3,500 00
Freestone	Quarter mile below Piney Bayou	4,000 00
Peytona	Near Eureka Landing	4,000 00
Natchez	One mile below Bertonia Landing	4,500 00
M. E. Keene	French Bend	4,000 00
Total		40,500 00
Engineering and contingencies, ten per cent		4,050 00
Grand total		44,550 00

The above estimate is based upon the work being let out by contract. Should the Government build a suitable steamboat, as estimated below, and employ its own workmen in removing the wrecks, the estimated cost would be \$30,000, and a saving of nearly \$15,000 would be made.

The third class of obstructions are the snags, and are located as follows :

Snags.	Location.	Snags.	Location.
Bed of snags...	Near mouth of Old River.	Bed of snags...	Twelve-mile Bayou.
Do.....	Steel's Bayou.	Do.....	Wilton's Landing.
Do.....	Haynes's Bluff.	Do.....	Elm Grove.
Do.....	Extending from Collins's Bayou	Do.....	Woodbury.
	to Little Sunflower.	Do.....	Piney Creek.
Do.....	Eldorado Bar.	Do.....	Eureka.
Do.....	Clark's Landing.	Do.....	Belle Prairie.
Do.....	Lake George Bayou.	Do.....	Wasp Lake.
Do.....	Extending from Richard's Bayou	Do.....	Eagle Lake.
	to O'Neal's Creek.	Do.....	Alligator Slough.

For the removal of the snags a snag-boat would require to be built. I estimate for three classes of boats, which would be suitable for this river.

1st. Iron stern-wheel steamboat 130 feet long, 34 feet wide, and 1 foot 9 inches draught, fitted up complete for wrecking and snagging; cost, \$45,000.

2d. Wood stern-wheel steamboat of above dimensions and fitting; cost, \$35,000.

3d. Crane-boat 95 feet long, 22 feet wide, and 1 foot 6 inches draught, fitted up complete for snagging; only cost \$7,000.

The cost of executing the work required on the river, including cutting overhanging trees, I estimate by each description of boat to be as follows :

By iron steamboat.

Cost of iron steamboat	\$45,000
Two seasons' work, six months each, at \$2,700 per month	32,400
Removing eleven wrecks	30,000
	107,400
Engineering and contingencies 10 per cent	10,740
	118,140
Deduct value of steamboat after four years' service	30,000
	88,140

By wood steamboat.

Cost of steamboat	\$35,000
Two seasons' work, six months each, at \$2,700 per month	32,400
Removing eleven wrecks	30,000
	97,400
Engineering and contingencies	9,740
	107,140
Deduct value of steamboat after four years' service	10,000
	97,140

By crane-boat, removing snags and leaning trees only :

Cost of crane-boat	\$7, 000
One boat for workman's quarters.....	700
Three seasons' work, six months each, at \$2,200 per month.....	39, 600
	47, 300
Engineering and contingencies 10 per cent.....	4, 730
	52, 030

The fourth class of obstructions are the overhanging trees. I submit estimate for their removal :

Two boats fitted up complete, with accommodation for workmen	\$1, 500
Tools, &c	500
Six months' work, at \$1,500 per month.....	9, 000
	11, 000
Engineering and contingencies.....	1, 100
	12, 100

Upward of 100,000 bales of cotton are made annually in the Yazoo Valley, and the river runs through a well-settled country.

The five following counties chiefly depend on the river for their exports and in-ports, viz :

County.	Population.	Taxable value of property.
Yazoo	17, 297	\$4, 800, 000
Holmes	19, 360	3, 600, 000
Issaquena	6, 887	2, 300, 000
Washington	14, 569	6, 500, 000
Leflore	No return.	1, 800, 000
Total		19, 000, 000

Considering that the Yazoo River has never had any work done on it for the removal of natural obstructions, it is in a fair navigable condition. Last year \$40,000 was appropriated for the removal of artificial obstructions, placed there during the war, and no other appropriation has ever been made for this river by Congress.

By appropriating \$120,000, extending over a period of four years, a thorough improvement would be made on the river, which would be sufficient for many years to come. By appropriating \$52,000, extending over a period of three years, the snags and overhanging trees could be removed. By appropriating \$12,000 the overhanging trees could be cut down.

I have the honor to remain, very respectfully,

JOSEPH BURNEY.

Maj. W. H. H. BENYAURD,
Captain of Engineers, U. S. A.

APPENDIX M.

ANNUAL REPORT OF MAJOR CHARLES R. SUTER, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1874.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Mo., August 14, 1874.

GENERAL: I have the honor to submit herewith my annual report upon the operations committed to my charge during the fiscal year ending June 30, 1874.

I am, general, very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

M I.

IMPROVING MISSISSIPPI, MISSOURI, AND ARKANSAS RIVERS.

OPERATIONS IN THE MISSOURI RIVER.

The snag boats Long and De Russy were assigned to this field.

The De Russy passed four times over her beat, which extended from Booneville to Kansas City, and twice over the portion of river between Booneville and Rocheport.

The Long passed twice over that portion of the river lying between Rocheport and the mouth. The operations of this latter boat were much impeded by the sickness prevailing among her crew.

Three months' snag-boat work was devoted to the Missouri, and as much good accomplished as could be expected, but the time available was quite inadequate to the work required. This must continue to be the case until the annual appropriations are increased.

Table of work done in the Missouri River.

Name of boats.	No. of snags pulled.	Weight in tons of 2,000 pounds.	No. of trees cut.	Drift-piles removed.	No. of miles run.
R. E. De Russy	410	3, 073. 6	1, 181	9	1, 204
S. H. Long	431	5, 533. 0	237	5	498
Total	841	8, 606. 6	1, 408	14	1, 702

OPERATIONS IN THE MISSISSIPPI RIVER.

The snag-boats Long and De Russy and snag and dredge boat Octavia were assigned to this field.

The snag-boat Long worked from Cairo to Saint Louis previous to entering Missouri River, and also after her return from that stream.

During the month of September she was detailed, at the request of Maj. William E. Merrill, Corps of Engineers, to do a few days' work in the Ohio River.

In November she was transferred to the Lower Mississippi, working between Helena and Vicksburg, and was finally laid up December 31, 1873.

The snag-boat De Russy began work in the Mississippi in November; her beat extended from Cairo to Helena; she passed over her beat twice, and was finally laid up December 31, 1873.

The snag and dredge boat Octavia was sent to the Upper Mississippi, and worked four weeks during September and October.

Six months' work in all was devoted to the Mississippi, in accordance with the programme of operations approved by the Department.

Table of work done in the Mississippi River.

Name of boats.	No. of snags pulled.	Weight in tons of 2,000 pounds.	No. of trees cut.	Drift-piles removed.	No. of miles run.
R. E. De Russy	322	5, 333. 9	515	6	1, 150
S. H. Long	304	6, 509. 1	.....	.....	2, 120
Octavia	4	37. 3	.....	.....	1, 710
Total	630	11, 880. 3	515	6	5, 080

OPERATIONS IN THE ARKANSAS RIVER.

It had been designed to devote two months' work to this stream, but the new iron snag-boat not having been completed, it was deemed a waste of money to send in either of the wooden ones, as they could only venture a few miles from the mouth, and could, therefore, accomplish nothing of importance.

Recapitulation of work done during season.

Name of rivers.	No. of snags pulled.	Weight in tons of 2,000 pounds.	No. of trees cut.	Drift-piles removed.	No. of miles run.
Missouri River.....	841	8,606.6	1,408	14	1,702
Mississippi River.....	630	11,880.3	515	6	5,040
Total.....	1,471	20,486.9	1,923	20	6,742

CONSTRUCTION OF IRON-HULLED SNAG-BOAT.

Owing to delays incident to high water, strikes at the rolling-mills, &c., the contractor for the iron snag-boat in course of construction at Cincinnati has as yet been unable to finish the boat. Various extensions were granted him, the last one fixing the 30th of June, 1874, as the day for the delivery of the boat. At that date, however, she was not finished, and, moreover, the Ohio River had fallen so low that it was a matter of some uncertainty when the boat could be got over the falls at Louisville. She is too wide to go through the locks of the canal. It is hoped, however, that we will, at least, be able to get her out in the autumn. Her machinery is all ready to be set up, and when once delivered to the Government a few weeks' work will fit her for service.

As far as can be at present predicted, the result of this experiment in snag-boat building promises good results.

The draught of water will not exceed $2\frac{1}{2}$ feet, while the wooden boats built in 1868 now draw 5 feet. Moreover, the new boat has the advantage of enormous structural strength and stiffness as well as an almost indestructible hull.

I deem it of the utmost importance to this work that another boat of the same dimensions, and one of smaller size, should be provided as soon as possible, to replace the S. H. Long and the Octavia.

These boats are now almost useless on account of their excessive draught of water, and the yearly cost of keeping up their wooden hulls is a great tax upon the small annual appropriations.

If these boats were at my disposal, and the wooden snag-boat R. E. De Russey fitted up as a wrecking-boat, I should be able to make a far better use of even the small annual appropriations now granted us, but I do not think that these are at all commensurate with the extent and importance of this work.

To fulfill the demands of commerce would require that for several years the whole fleet should be kept in the field for at least eight months. This is the minimum at which efficiency can be secured, and until it is done, we shall fail to satisfy the demands and wants of the navigation interest.

In order to show that there is something more than a mere gain in strength and lightness by building these snag-boats of iron, I submit herewith a comparative statement of the cost of building and maintaining wooden and iron hulls for this work. The figures for wooden hulls are from our actual experience, as also those for the cost of iron hulls.

The expense of repairs for these latter is taken from the best sources

of information at my command, and is believed to be ample, if not excessive.

I have taken the life of the iron boat at thirty years, although there are many instances of iron boats still sound and staunch at a greater age than this.

As the wooden hull, during this period of thirty years, would have to be renewed three times, and as the current annual repairs would be very much greater, I find that, assuming the running expenses to be the same, the difference for a full year's work would average \$10,238 in favor of the iron hull. This would be equivalent to three month's field-work.

It is, of course, generally known that, with the same dimensions and strength, an iron hull will be far lighter than a wooden one; but to show the peculiar advantage, not to say necessity, of using iron hulls for our snag-boats, I will cite but one more fact.

I think our experience justifies us in assuming that 2½ feet is the reatest admissible draught for an efficient snag-boat, and that 2-feet draught would be better for small streams.

The iron snag-boat J. N. Macomb will draw 2½ feet. Her length is 175 feet, and her beam 62. A wooden hull of same dimensions would draw about 3 feet 2 inches, and with the same power would be of much lower speed.

To bring a wooden boat out on the same draught as the J. N. Macomb, and have her equally fast, would require a hull 250 feet long and 62 feet beam, at the very least; and my experience with the old boats leads me to doubt the possibility of making such a boat strong enough for the work required, even if her immense size did not render her practically worthless.

To get out a wooden hull on a draught of 2 feet would, I think, be impossible, although a very useful powerful iron snag-boat can be built which will not exceed that draught. Such a boat is now being built by Maj. William E. Merrill, Corps of Engineers and I have recommended one of similar size to carry the machinery of the Octavia.

Wooden hull.

First ten years:		
To original cost	\$68,922 61	
To necessary repairs at end of five years	50,000 00	
To current repairs, ten years, at ten months each, one hundred months, at \$576.25 per month	57,625 00	
	176,547 61	
By credit for value of hull	1,000 00	
		\$175,547 61
Second ten years, (new hull:)		
To original cost, less \$6,000 credited for value of machinery...	\$62,922 61	
To necessary repairs at end of five years	50,000 00	
To current repairs as above, one hundred months, at \$576.25 per month	57,625 00	
	170,547 61	
By credit for value of hull	1,000 00	
		169,547 61
Third ten years, (new hull:)		
To original cost, less \$3,000 credited for value of machinery...	\$65,922 61	
To necessary repairs at end of five years	50,000 00	
To current repairs as above, one hundred months, at \$576.25 per month	57,625 00	
	173,547 61	
By credit for value of hull and machinery	1,500 00	
		172,047 61
Total for thirty years		517,142 83
Total cost for one year, \$17,238.09.		

Iron hull.

First ten years:	
To original cost	\$130,000 00
To current repairs, ten years, at \$2,000 per year.....	20,000 00
	<u>\$150,000 00</u>
Second ten years:	
To necessary repairs at end of ten years	\$15,000 00
To current repairs, ten years, at \$2,000 per year.....	20,000 00
	<u>35,000 00</u>
Third ten years:	
To necessary repairs at end of twenty years	\$20,000 00
To current repairs, ten years, at \$2,000 per year.....	20,000 00
	<u>40,000 00</u>
By credit, value of old iron in hull	15,000 00
	<u>25,000 00</u>
Total for thirty years.....	210,000 00
Total cost for one year, \$7,000.	

Wooden boat.

To cost per annum	\$17,238 09
To running expenses, full year.....	40,000 00
	<u>\$57,238 09</u>

Iron boat.

To cost per annum	\$7,000 00
To running expense full year	40,000 00
	<u>47,000 00</u>
Difference in favor of iron for one year	10,238 09

OPERATIONS DURING THE COMING YEAR.

Two snag-boats only can be put in the field. One of these will remain entirely in the Mississippi, working there eight months; the other one will work in the Missouri and Arkansas, four months in each. The J. N. Macomb, when completed, will take the place of this latter boat.

ESTIMATE.

Amount required for fiscal year ending June 30, 1876.

For one large iron-hulled snag-boat, to carry machinery of one of present wooden boats	\$140,000
For one small iron-hulled snag-boat, to carry machinery of one of present wooden boats	105,000
For working expenses for four boats, eight months each, at \$4,000 per month.	128,000
Total amount required	373,000

Financial statement.

Balance in Treasury of United States July 1, 1873	\$120,988 00
Amount in hands of officer and subject to his check.....	57,301 23
Amount appropriated by act approved June 23, 1874	100,000 00
Amount expended during the fiscal year ending June 30, 1874	149,389 34
Amount available July 1, 1874	106,399 89
Amount required for fiscal year ending June 30, 1876.....	373,000 00

M 2.

IMPROVEMENT OF WHITE AND SAINT FRANCIS RIVERS.

The snag-boat Octavia was detailed for this work, and left for White River January 1, 1874.

She worked up to Jacksonport, which is practically the head of navi-

gation on this stream, then worked down, and left the river February 4. She proceeded at once to St. Francis River, and worked up to Wittsburg. By this time the southern rivers had all risen so much as to render further work impossible. The boat was therefore ordered in, and laid up at the end of February, 1874.

Table of work done in White and St. Francis Rivers.

Rivers.	Number of snags pulled.	Weight in tons of 2,000 pounds.	Number of trees cut.	Drift piles removed.	Number of miles run.
White River	51	393.2	1,592	1	750
St. Francis River	38	217.2	76	0	288
Total.....	87	611.1	1,668	1	1,038

Although no appropriations have been made to continue this work, yet the fact that work is ordered on White River above Jacksonport shows a disposition on the part of Congress to keep up the improvement of this stream at least. Work in this river to be effective should be done at a low stage of water, and will require a light, powerful snag-boat to accomplish it. An iron-hulled boat of the smaller class—as mentioned in report for improving Mississippi, Missouri, and Arkansas Rivers—will be suitable for the purpose. As much snagging is still needed here, I submit herewith estimates for the boat and running expenses.

ESTIMATE.

Amount required for fiscal year ending June 30, 1876.

For one small iron-hulled snag-boat, new throughout	\$130,000
For labor of two snag-boats, eight months each, at \$4,000 each per month ...	64,000
Total amount required.....	194,000

Financial statement.

Balance in Treasury of United States July 1, 1873	\$41,000 00
Amount in hands of officer and subject to his check	5,563 79
Amount expended during the fiscal year ending June 30, 1874	42,595 12
Amount available July 1, 1874	3,973 67
Amount required for fiscal year ending June 30, 1876.....	194,000 00

M 3.

EXAMINATION OF FORKED DEER RIVER, BELOW DYERSBURG, TENNESSEE.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Mo., February 24, 1874.

GENERAL: I have the honor to submit herewith the report of an examination of the Forked Deer River below Dyersburgh, Tenn., made under my direction by Mr. Oscar Liebrecht, assistant engineer.

Mr. Liebrecht's report gives a sufficiently clear idea of the character of this little stream, and the commerce likely to be benefited by its im-

provement. At the time his examination was made, the river had not reached its lowest stage, so that the soundings, indicated on the accompanying map, are reduced to the *supposed* low-water plane, and are probably in excess of the truth.

Even with this margin, however, we find that the stream has on some of the shoals a maximum low-water depth not exceeding 14 inches, and that the actual width of channel-way in the bends, where the water is comparatively deep, is only 25 feet, and even this width is frequently reduced by accumulations of snags, leaning trees, &c.

Near the lower end of the river there is a large accumulation of snags, &c., which completely dam the stream.

It is therefore evident that a great deal of work would be required to remove these obstructions, and we must still consider the question of the navigable depth which can be obtained after their removal.

Mr. Liebrecht states that near White Oak Landing two small islands divide the river. At the foot of the lower island a bar has formed, which at low water has only a maximum depth of 14 inches. The width between banks is 100 feet.

He thinks that by closing the chutes behind the two islands this bar would be washed away and there would be, at all times, at least 3 feet of water to Dyersburg. This, however, is very problematical.

The entire slope of the river is given as 19 feet in a distance of 30 miles, which is an average slope of about $7\frac{1}{2}$ inches to a mile. Moreover, during low water the current in the pools is scarcely perceptible. It follows that this great slope must be mainly concentrated on the shoals, which, therefore, act as a series of dams. Now, if a channel be cut or washed through such a bar, the effect will be precisely the same as if a breach were made in an artificial dam. If the supply of water from above is great and the size of the breach small, the level above the bar will not be much affected; but if the supply is limited, then the level will be gradually drawn down until a new condition of equilibrium is reached. When this occurs, it will be found that the artificial channel is not only shoaler than before, but the navigable depth and width in the pools are greatly reduced, and, generally, other bars which had before been deeply submerged are now brought sufficiently near the surface to be troublesome. The actual amount of enlargement of waterway allowable will depend on the discharge of the stream at extreme low water. This could not be obtained by Mr. Liebrecht, owing to the snags, &c., which interfered with the passage of his floats; but judging from the data which he gives, I conclude that perhaps an increase of depth of 3 or 4 inches might be obtained during the months when navigation is now suspended by low water. There would still remain the trouble caused by the excessively tortuous course of the stream, which, of course, would not be obviated, unless slack-water navigation were adopted.

Of snags, &c., Mr. Liebrecht states that he counted 3,700, but as the number of snags concealed by the water is always much greater than the number of those which appear above the surface, this gives but an imperfect idea of the work likely to be needed in this line.

Mr. Liebrecht also thinks that it would be desirable to close up the two old channels through which the Forked Deer formerly discharged into the Mississippi. Whenever the Mississippi rises sufficiently, it backs up into Forked Deer and flows down these old channels, carrying drift, &c., and forming bars in the main channel of the stream. The cross-current at the head of these chutes is also troublesome to the small boats employed in the navigation of the river.

The estimates submitted by Mr. Liebrecht are given in his report. He estimates—

For snagging	\$35,300
For dams	7,250
Add 25 per cent. for contingencies	10,640
Total	53,190

I do not consider either of these estimates high enough. I estimate—

For snagging	\$46,000
For dams	11,000
	57,000
Add 25 per cent. for contingencies	14,250
Total	71,250

The work would require about three seasons to complete it, and would probably require small annual appropriations to prevent new accumulations of snags, to keep up the dams, &c.

Now, the only parties who would be benefited by this improvement are the inhabitants of Dyer and Lauderdale Counties, Tennessee. They have been hitherto mainly dependent on the river for transportation. When that was closed to them they have been obliged to haul everything to and from the nearest railroad-depots. This latter method is, of course, very expensive, and the freight-rates on the small steamers running on the river are very high—probably to cover their expenses when lying idle for nearly half the year.

The Paducah and Memphis Railroad has now been extended to Dyersburgh, and will soon be in operation. This will, of course, materially improve the condition of affairs.

It only remains, then, to consider the benefit likely to be derived from the improvement of the river.

The annual exports and imports per Forked Deer River Mr. Liebrecht values at \$743,000, on which the freight paid amounts to about \$53,000.

In case the river could be so improved as to give 3 feet all the year round, freights would be reduced about 25 per cent., an annual saving of \$13,250. But it would be impossible to give such favorable conditions without resorting to slack-water navigation, a project in itself very costly and not definitely known to be feasible. The discharge of the river at lowest stage must be known before we can decide whether it would furnish sufficient water for lockage.

Under the most favorable circumstances, however, and supposing the river to furnish enough water for this purpose, a system of locks and dams could not be put in for less than \$200,000.

By removing the snags, cutting leaning timber, &c., and constructing a few small dams and dikes, a depth of about 18 inches could probably be secured, at an estimated cost, as before stated, of \$71,250. This, it is thought, might reduce freight-rates about 10 per cent., and in this case the annual saving would be about \$5,300.

As before stated, the work would only be of local benefit, as the stream is merely an outlet for the two counties of Dyer and Lauderdale, and, of course, it cannot compare with the vast interests connected with the Mississippi and its principal tributaries. Moreover, it is utterly useless, with streams of this size and kind, to make small appropriations of a few thousand dollars, as has been frequently done heretofore. Either

the whole amount deemed necessary to make a thorough improvement should be appropriated or none at all.

The foregoing estimate is deemed sufficient to accomplish the work designated, but, for the reasons already given, I do not deem the improvement of sufficient importance to justify the Government in undertaking it.

No appropriation is recommended.

I am, general, very respectfully, your obedient servant,

CHAS. R. SUTER,

Major of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Report of Mr. Oscar Liebrecht, Assistant Engineer.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Mo., February 20, 1874.

MAJOR: As directed by order of this office, dated September 12, 1873, I have made the survey of Forked Deer River, in Tennessee, and now beg to submit to you the result of my investigation.

Forked Deer River is formed by the confluence of several streams called the Little North Fork, the Middle Fork, and the South Fork of Forked Deer. The Little North Fork, which has its source in Gibson County, and the Middle Fork, rising in Carroll County, meet some eighteen miles above Dyersburgh, and from that point they continue their common course under the name of North Fork of Forked Deer. About eight miles below Dyersburg, this North Fork unites with the South Fork, which is the most important of all, and which comes from Henderson and McNairy Counties.

The South Fork was formerly navigable as far as Jackson, Tenn., but having been bridged in different places for railroad purposes, it can no longer be frequented by steamboats, and is at present used, on a stretch of about twenty-five miles, only for floating rafts and carrying lumber by means of flat-boats.

On the North Fork, Dyersburg, the county-seat of Dyer County, and a town of about twelve hundred souls, is the head of steamboat navigation, and it was from that point downward to the confluence of the Forked Deer and Obion Rivers that the survey was made, the whole portion examined having a length of about thirty miles.

The general direction of the flow of Forked River is south-southwest from Dyersburgh to a point called Key Corner, (twenty and three-quarter miles below Dyersburgh,) and thence to the mouth, almost due west. But, as stated, these directions are only general, for the river pursues an extremely sinuous course, and presents many more or less sharp bends, which render navigation with boats of even moderate size rather difficult, especially during the lower stages of water.

From the mouth of the South Fork down to the Obion, Forked Deer River forms the boundary-line between Dyer and Lauderdale Counties, which, be it remembered here, are alone directly interested in its improvement.

The country traversed by the examined portion of the river is both an agricultural and timber one; but directly adjacent to it only about 700 acres are under cultivation. The nature of the soil, composed of clayey earth, with a small addition of sand, is very favorable to the growth of cotton, which represents the principal farming product of the country. Corn, tobacco, pea-nuts, potatoes, hay, cattle, and hogs are also raised in more or less considerable quantities; and besides one grist-mill in Dyersburg, several large saw-mills are found on both forks of Forked Deer, as well as on the Obion River.

On the right side of the river, from Dyersburg to a point somewhat above Tower's Landing, (situated 10½ miles downward,) the bottom-lands, which vary from 6 to 15 feet in height, have but little width, and are bordered by uplands, which often approach closely to the river; but below said point the whole country comprised between the Forked Deer and Obion Rivers is annually overflowed during the high-water periods, with the exception of some more elevated tracts of land, on which are found several very fine farms.

On the left hand a range of bluffs, alternately lower and higher, called the O'Keno Bluffs, and commencing near Columbus, Ky., run along the river at a distance from it of from 60 feet to one mile, and strike it in two places, viz, Marr's Mill and Key Corner. At the latter point they leave the river to take a more southwesterly direction, and terminate near Fort Pillow, on the Mississippi.

Fine timber, consisting of poplar, cypress, oak, elm, ash, sycamore, hickory, white birch, gum, and willow grows everywhere along the Forked Deer, and forms, after cotton, the most important article of trade of that section of the State.

The banks of the river have generally a slope of 1 in 1, their height varying from 6 to 15 feet, though in some places they are almost flat, and in others rise to a height of 20 feet and more. Near the outlet their elevation is the same as those of the Mississippi, into which the Forked Deer entered—or rather was made to enter, by means of a through-cut—before the latter had entirely abandoned its old bed to flow only through Needham's Cut-Off.*

In the upper part of the river the banks are corroded but in a few places, while more downward, especially in and near the through-cut, (known as "the canal,") where they stand more or less steep, they bear evident signs of permanent abrasion.

From Dyersburg to Key Corner the bottom of the river is of the same nature as the surrounding land, namely, clayey earth mixed with sand. In some places, however, it is sandy, here and there even gravelly. Below Key Corner, down to the mouth, it is covered with pure whitish siliceous sand, numerous deposits of which appear, at low water, along the banks, mainly in the bends. Some accumulations have also formed on the bottom itself of the river, the most important being the bar of White Oak Landing, (6½ miles below Key Corner,) which, on a distance of 300 feet from the foot of the second island downward, occupies the whole width of the river, and is a serious obstruction to low-water navigation, the depth of water at the shallowest place not exceeding 1.2 feet in the channel.

From Dyersburg to the South Fork the width of the river varies from 60 to 115 feet, with an average of 85 feet. From the latter point to the mouth, this width ranges between 80 and 180 feet, and averages from 130 to 140 feet. In different places, however, especially in bends, are found deep recesses or basins, which formed during the earthquake of 1811-'12, when the soil sunk down at those places. In some of said basins the water is from 30 to 40 feet deep. The lakes to which lead the Lost and Old Channels of Forked Deer, of which mention will be made hereafter, were originated by the same cause.

Owing to the numerous snags imbedded in the river, the trees fallen right across it, and the resulting accumulations of matter of all kinds, the water-way is often deviated from its natural location, and has become very irregular. Its width at low water is about 25 feet, but in many places the snags and other obstructions have left only a much narrower channel, through which the flat-boats that run during the lower stages of water work their way with great difficulty, sometimes even not without danger. The two worst places in this respect are near the upper island of White Oak Landing, and especially between the Old and Lost Channels of Forked Deer, where the snags and logs have accumulated in a most deplorable manner.

The depth of water in the channel at low water varies from 3 to 10 feet; but this depth is often either less or much greater, the least on the bar being, as heretofore stated, 1.2 feet, and the greatest in pools, about 22 feet.

The water-slope of the examined portion of Forked Deer is about 19 feet, the heaviest inclination being found in the lower part of its course, i. e., from Key Corner to the outlet.

The highest water, which occurred in 1854, rose, as far as I could ascertain—

At Dyersburg to a height of	24½ feet above low water.
At Tower's Landing to a height of	22 feet above low water.
At Key Corner to a height of	22½ feet above low water.
At the mouth to a height of	37 feet above low water.

In the lower part of the river, namely, from a point a little above Tower's Landing, extreme high water occurs when the Mississippi reaches its highest stage, and no other cause then contributes to raise, in that section, the level of the river. But above said point the high-water mark is reached only by the combined effect of the high stage of the Mississippi and of "head rises" of the Forked Deer; and it has happened that when the former was high and the Forked Deer low the latter was backed up so as to rise, at Dyersburg, 18 feet above low water.

Two screw-steamers, of seventy-five tons burden, ply between Dyersburg and Hale's Point, on the Mississippi, whenever the river gets high enough; that is, for from six to seven months in the year. They measure 80 feet long by 16 feet beam, and when fully loaded have a draught of 3 feet. A third steamer, more especially destined for the lumber trade, of three hundred tons register, and measuring 120 feet long by 24 feet beam, with 5½ to 6 feet draught, is constructing, and will be ready this month. Besides these steamers, a "keel-boat," 80 feet long by 14 feet beam, bearing sixty tons, runs during the lower stages of water, when steam navigation is suspended. With a full

* The upper part of this old channel of the Mississippi is already filled up as far as the former mouth of Union River, and the lower part, grown considerably narrower, now forms the lower end of that river.

load it draws 2 feet, with a half load only 13 inches. I here repeat what I have said before, viz, that on account of the shortness of some bends the average depth of water, during the lower stages of the river, &c., steamers of larger dimensions than the one now in construction will not be able to trade with advantage on Forked Deer River, whatever improvements may be undertaken; and, though I was told that last year a barge 160 by 32 feet, with 5½ feet draught, came up to Dyersburg, it can have been only with the utmost difficulty and a great loss of time. Besides—and this remark I underscore—the steamers now in service are amply sufficient, and will remain so for some time, for carrying all the freight that takes or will take the way of the river.

The freights now paid from Dyersburg to Hale's Point are as follows:

Tobacco, per hogshead, (from 17 to 20 cwt.)	\$5 00
Cotton, per bale, (500 pounds)	1 50
Lumber, per 100 feet	5 00
Pound-freight, per cwt	40
Corn, per sack, (two bushels)	15

These rates, which are evidently exorbitant, could and would be considerably reduced if the river were made permanently navigable, so that the steamers might run all the year round, and not be obliged to compensate the lost time by higher freights.

Annexed you will find a copy of a letter directed to me by the Board of Trade of Dyer County, in answer to my request for information regarding the amount of trade carried on by means of Forked Deer River. The enormous quantities reported being far from agreeing with those facts which I had been able to collect on the same subject, I investigated the correctness of the statement, and found the amounts therein laid down to be entirely unreliable.

The following figures, resulting from information received from different trustworthy sources, are what I think a fair approximation to reality.

Area of land in Dyer and Lauderdale Counties under cultivation, not more, but probably less, than one-eighth of the total area.

ANNUAL EXPORTS BY RIVER.

Cotton, 5,000 bales, value	\$300,000	instead of 20,000 bales	*\$14,000,000
Tobacco, 400 hogsheads, value	40,000	instead of 500 hogsheads	62,500
Corn, 1,000 barrels, value	3,000	instead of 20,000 barrels	60,000
Peanuts, 1,000 sacks, value	4,000	instead of 2,000 sacks	8,240
Hay, 25 tons, value	500	instead of 500 tons	10,000
Cattle, 200 head, value	6,000	instead of 2,000 head	20,000
Hogs, value		instead of 5,000 head	90,000
Potatoes, 1,000 bushels, value	1,000	instead of 10,000 bushels	10,000
Shingles, 75,000, value	375	instead of 500,000	2,500
Laths, 1,000,000, value	3,000	instead of 1,000,000	3,000
Lumber, 2,000,000 feet, value	30,000	instead of 15,000,000	225,000
Timber-logs, 500,000 feet, value	4,800	instead of 20,000,000	140,000
Total value	392,675	instead of	14,631,240
		or rather	2,031,240

Annual imports by river worth about \$350,000, instead of \$1,700,000.

The aggregate value of the shipments per Forked Deer River thus amounts to about \$743,000, in lieu of \$3,732,000, indicated by the board of trade.

As to the views expressed in the report regarding the general condition and prospects of the country, they probably deserve credit, and there is no doubt that the improvement of Forked Deer would largely contribute to the development of the district through which it flows. On the other hand, a regular and uninterrupted service of steamers all the year round would not only cause those goods which are now hauled overland, at a heavy expense, to or from distant railroad depots, to find their way to the river, but it would also have a salutary influence on the tariffs of the Paducah and Memphis Railroad, which passes at Dyersburg, and will soon be in operation.

OBSTRUCTIONS AND IMPROVEMENTS—ESTIMATE OF COSTS.

The principal obstructions to navigation at high, and especially at mean and low, water, are the snags, logs, stumps, and fallen trees, of which I counted about 3,700. Their real number is probably much larger than the ones stated, but a great many, not being in the way, may be left where they are without endangering the future good condition of the river. Besides the removal of the snags, &c., some other improvements are necessary, namely:

*Probably for \$1,400,000.

A.—REMOVAL OF THE SAND-BAR AT THE FOOT OF WHITE-OAK LANDING.

Above that bar, caused by an expansion of the river, an island has formed, and to make the bar disappear it will, I think, be sufficient to close up, by means of a low dam, the secondary branch, which retains 1 foot of water at the lowest stage of the river. By thus compelling the latter to flow at low water through one bed, the current will probably become strong enough to gradually wear off the obstruction. Should this remedy not prove sufficient, a small spur-dam would certainly bring about the desired result. But in order to prevent the shifting of the bar from its present location toward the upper end of White-Oak Landing, (one-third of a mile above,) where the river also expands and has formed an island, it will be prudent to close up there, too, the side channel. Several other little bars, or rather deposits, exist in the river, but they are occasioned only by snags and fallen trees, and would be washed away by the river itself, the cause of their formation being removed.

B.—CUTTING OF LEANING TREES

In some places where they overhang the channel.

C.—CONSTRUCTION OF DAMS AT THE LOST AND OLD CHANNELS OF FORKED DEER.

Forked Deer River had not always the present bed in the lower part of its course. Probably long ago it flowed through what is now called the Lost Channel of Forked Deer, but left it and found the Old Channel, leading, like the Lost Channel, to Wood Lake. Passing through this lake, it entered into the Open Lake, and after leaving the latter divided itself into two branches, both of which discharged into the Mississippi, the upper one near the head of Island No. 26, and the other two-and-one-half miles above Ashport.

But about thirty-five years ago some interested parties, in order to reach more quickly the Mississippi and Obion Rivers, undertook to shorten the course of the Forked Deer by making a through cut at a place where the latter drew very near the old channel of the Mississippi, at Needham's Cut-Off. This plan, the authors of which had evidently no pretension to engineering skill, was besides carried out in a most objectionable manner, for not only the new mouth of Forked Deer was directed against the stream of the Mississippi, (now Obion River,) but also the old channels of Forked Deer were left open. The result of this piece of work was to disturb the normal condition of the whole lower portion of Forked Deer, and though the evil gradually decreased as the old channels filled up, still it is desirable, if not necessary, to make it disappear altogether.

As matters stand now the situation is the following:

When, namely, the Forked Deer begins to rise above the bottom of the Old and Lost Channels, a sort of draught forms in the lower part of the river toward these channels, down which the water then flows with more or less violence, according as it is more or less high and rises more or less quickly. This draught, which lasts until the whole country traversed by the old channels is overflowed, can, I think, never be very powerful, and would probably not affect larger steamers; but still it becomes at a certain moment strong enough to render difficult the steering of the little crafts which trade on the Forked Deer, and which have not a great steam-power. It must, besides, not be forgotten that in the lower part of the river the slope of water is rather heavy, and precisely between the Lost and Old Channels there is a sort of chute, caused by the raft that has formed there, which two circumstances are not made to facilitate navigation in those parts. By closing up both channels with dams reaching to the top of the banks the draught would be stopped, and the danger of new obstructions forming in the river near these channels be considerably lessened.

Said dams might be made of piling and stone, if any of the latter can be found at Key Corner, in the bluffs; if not, the stone would have to be replaced by snags, brush, sand, and clay, properly beaten down.

Though the usefulness of the latter work is not to be doubted, the most important part of the improvement of Forked Deer evidently consists in the removal of the snags and of the sand-bar at White-Oak Landing; and, being thus cleared, the river will become navigable all the year for such steamers as now frequent it.

For executing this improvement I propose to make use of a flat-boat, carrying a hand-crane, and provided with the necessary outfit of tools and rigging for pulling out the snags and cutting trees. The monthly expenditure for running such a boat would be—

Supervising engineer.....	\$200 00
Mate and 1 foreman.....	250 00
15 laborers, at \$60.....	900 00
2 cooks.....	100 00
Subsistence of 20 men, at \$1 per day.....	600 00
Total.....	2,050 00

Estimate of cost for improving Forked Deer River from Dyersburg to the mouth.

Flat-boat	\$500 00
Rigging and tools	1,500 00
Repairs	500 00
Removing snags and cutting trees, 15 months' work, at \$2,055 per month	30,750 00
1 additional month for passage down stream	2,050 00
Pile-driver	500 00
250 linear feet of low dam	750 00
300 linear feet of high dam	6,000 00
	42,550 00
5 per cent. for contingencies	10,640 00
Total	53,190 00

In conclusion of this report, I add that large sums of money, aggregating in all \$43,000, have been appropriated, at different times within the last twenty years, by the legislature of Tennessee, for the improvement of Forked Deer River. But these appropriations were expended without benefit to the river, and the people of Dyer and Lauderdale Counties now look to the General Government for obtaining what, in spite of great sacrifices, they have not been able to bring about themselves.

Very respectfully, your obedient servant,

O. LINDBRECHT,
Assistant Engineer.

Major CHARLES R. SUTER,
Corps of Engineers, U. S. A.

Letter of Secretary Dyer County Chamber of Commerce.

DYERSBURGH, TENN., November 13, 1873.

DEAR SIR: Annexed hereto I submit a report showing the annual productions of the counties of Lauderdale and Dyer, approximating their value from sources as reliable and authentic as can be possibly obtained.

Dyer County contains an area of 350,000 acres, with a population, according to the census-returns of 1870, of 14,389 souls.

It has been estimated that at least one-fourth of the entire area of Dyer County is at the present time under cultivation by a class of thrifty, industrious planters, whose exertions are yearly adding an enlarged area to the progress of agriculture. I may here remark that the fertility of the soil, not excelled by that of any other county in the State, is calling into our midst a large immigration from other States and counties less favored than our own, and has already a considerable increase to the population since the publication of the last census-returns of 1870.

As the productions of Dyer and Lauderdale are, so to speak, of the same character and value, I have thought proper, for brevity's sake, to aggregate the crops, or rather that proportion of those crops which is entirely dependent on the Forked Deer and its tributaries as their mode of transportation into foreign markets.

The subjoined list of the productions and their estimated values has been carefully prepared with a view to its entire accuracy:

Cotton shipped annually, 20,000 bales, value	\$14,000,000
Tobacco shipped annually, 500 hogsheads, value	62,500
Corn shipped annually, 20,000 barrels, value	60,000
Peanuts shipped annually, 2,000 sacks, value	8,240
Hay shipped annually, 500 tons, value	10,000
Cattle shipped annually, 2,000 head, value	25,000
Hogs shipped annually, 5,000 head, value	90,000
Potatoes shipped annually, 10,000 bushels, value	10,000
Shingles shipped annually, 500,000, value	2,500
Laths shipped annually, 1,000,000, value	3,000
Lumber shipped annually, 15,000,000 feet, value	225,000
Timber-logs shipped annually, 20,000,000 feet, value	140,000

As regards the quantity of tobacco raised in Dyer County, I may remark that in the year 1867 1,400 hogsheads were shipped from the port of Dyersburg alone.

From careful inquiry, made from the various merchants in Dyersburg and other commercial points in the county, I feel justified in placing the value of merchandise imported by river at a sum not less than \$1,700,000.

The merchandise thus imported consists chiefly of dry goods, hardware, groceries, and the usual articles of inland commerce of the United States.

It will not be outside the subject of inquiry to state that the closing of the river during a period of not less than four months in the year has, to a very considerable extent, militated against the interests of our citizens at large. This fact will explain itself when I state that during that period when the navigation of the river is impracticable, the only means of transportation available to the merchant is by wagons from the various railroad-depots, and this necessitates an expense which, in a very great measure, prevents them from disposing of their wares at as low a figure as if imported by river. It is, moreover, not to be doubted but that, if perpetual and continuous navigation of the Forked Deer can be obtained, nothing could serve more to enhance the value of the lands through which it flows, and it would become a blessing alike to the merchant and to the planter.

How this end can be accomplished it is not for me to suggest. On behalf of the counties of Dyer and Lauderdale, I have fairly and honestly laid before you the estimate of the productions of their soil, satisfied that their people will meet from your hands the justice the nature of their condition may demand.

I am, very respectfully,

W. HARRISON,
Secretary Dyer County Chamber of Commerce.

OSCAR LIEBRECHT, Esq.

P. S.—I omitted to mention above that the population of Lauderdale County numbers 11,370, according to the census of 1870.

W. H.

APPENDIX M 4.

REPORT OF MAJ. GEN. A. A. HUMPHREYS ON THE LEVEES OF THE MISSISSIPPI RIVER.

WASHINGTON CITY, *May 31, 1866.*

SIR: The examination and survey of the levees of the Mississippi River, consequent upon your instructions to me of December 11, 1865, having been completed, and the maps, &c., prepared, I submit a general view of the condition of the levees from the mouth of the Ohio River to the Gulf of Mexico, with an indication of those points where repairs are most urgently required to prevent great injury to the agricultural interests of the alluvial region of the Mississippi, as well as to commerce.

The topographical feature of the alluvial district in which the break is situated, the position and magnitude of the break, and the extent of cultivated land thereby rendered liable to inundation, have formed my guide in determining upon the points of repair.

I have excluded from consideration, as not coming under your instructions, those cases where the levees have been virtually destroyed along so great an extent of river-front that their repair would be practically the rebuilding of the levees of that section of country.

The great alluvial districts will be considered in the order in which they follow in descending the river from the head of the alluvial region near Cape Girardeau.

I.—ST. FRANCIS BOTTOM.

This district extends from the highlands of Cape Girardeau to the mouth of the St. Francis River, near the highlands of Helena. Its area is 6,300 square miles.

The levees from Cape Girardeau to New Madrid must be considered local in their character, since the extensive tertiary or diluvial prairies (land above overflow) running parallel to the general course of the river,

(one of which crosses the river at New Madrid and at Point Pleasant,) prevent any general overflow being caused by breaks in the levees in that extent of river-front. These levees are in ordinary condition.

From New Madrid to the boundary-line between Missouri and Arkansas the levees are in a tolerably good condition, and, as a portion of the levee-fund derived from the sale of the swamp-lands transferred to the States by the United States for the purposes of reclamation is said to remain unexpended, the condition of these levees requires no special attention.

The levees of Mississippi County, Arkansas, extending from the Missouri boundary-line to the Shawnee villages, (a point on the river above overflow, about thirty-five miles above Memphis,) need repair of breaks and closure of gaps at eight points. These openings in the levee are not of great extent, except at two points, one above and the other below the Shawnee villages; but some are of great depth.

This county has laid a tax of 10 cents per acre to repair the levees, which is deemed ample for the purpose.

For this reason, and for others that will appear in connection with what is stated concerning the levees below Memphis, I do not recommend any repairs by the United States in this county.

The following is a list of breaks and gaps in the levee on the front of Mississippi County:

Location.	Length, yards.	Depth in feet.
1. Bearfield Point, break.....	Small.	Small.
2. Mrs. McGavock's, near Osceola, break.....	Small.	Small.
3. Lamar's place, above Island No. 34, gap.....	30	20
4. Nodina place, bend of Island No. 34, gap.....	30	30
5. Morgan's and Craigbill's, below foot of Island No. 34, break.....	440	5
6. Pecan Point, at the foot of Island No. 35, (unleveed bayou—Barney's).....	30	30
7. Above Shawnee village, (high land in bend of Island No. 37).....	3,500	12-15
8. Below Shawnee village, (high land in bend of Island No. 37).....	5,300	10-12

From the Shawnee villages to the point opposite Memphis (part of Crittenden County river-front) there are but two breaks in the levee.

At Morris's, thirty miles above Memphis, 70 yards long, and 40 feet high.

At Fogleman's, seven miles above Memphis, 300 yards long, and from 12 to 15 feet high.

From the point opposite Memphis to the mouth of the St. Francis River (part of the fronts of Crittenden and Phillips Counties) the levees may be considered as virtually destroyed.

For thirty miles below Memphis one-half of the levees are gone, chiefly in the bends where they were highest.

For the remaining distance to the mouth of the St. Francis River (about forty miles) the levees may be considered entirely gone. For this whole length of river-front, some seventy or eighty miles in length, new levees will be required, placed farther back from the river-bank than the old levees.

The lower portion of the St. Francis bottom is subject to overflow by crevasse-water coming from breaks or gaps in the levees above.

The volume of this flood is sometimes so great that in returning to the river near the mouth of the St. Francis it washes away the levees on the Mississippi front. For this reason, until that portion of the St. Francis bottom above Memphis is securely leveed, a considerable part of the portion below it cannot be fully protected by front levees.

With a view to keep out the Mississippi flood from the interior alluvion, a project has been set on foot to construct a railroad from the bank of the Mississippi River opposite Memphis, along a succession of short ridges which run nearly parallel to the river, and about eight miles from its general course, up to the vicinity of Osceola, and thence diverge westward across the bottom-lands to connect with the Iron Mountain Railroad of Missouri. The road-bed is to serve as a levee, a branch from it to be extended to the levee on the river-bank above Osceola, when the road turns to cross the bottom-lands. The permanence of the road-bed is secured by its distance from the river-bank, eight miles; which is beyond the limit of caving banks, the chief source of the destruction of the levees.

Should this project be executed, immense tracts of interior bottom-land of great fertility would be reclaimed, and the plantations below Memphis would be exempted from overflow from the rear.

The temporary repair of levees in the condition of those of the St. Francis bottom below Memphis was not contemplated by your instructions.

The temporary repair at present of the two large gaps above Memphis would only confer a local benefit. The high ground in their vicinity restricts the spreading of the water flowing through them, which passes to the interior swamps and bayous, and thence to the mouth of the St. Francis.

The repair of the levees of the St. Francis bottom may be estimated at over 2,000,000 cubic yards of embankment, at the cost of more than \$800,000.

II.—FROM THE HIGH GROUND AT HELENA TO THE HIGH GROUND NEAR GAINES'S LANDING, ON THE RIGHT BANK OF THE MISSISSIPPI.

The levees of this comparatively limited alluvial tract must be considered local for any objects contemplated by the United States.

Between Helena and Bob's Bayou, near the mouth of White River, there are several breaks in the levee, some of which the planters are repairing, as between Helena and Oldtown ridge, and at Lacouia. At the latter place they are constructing rear levees, and are thus cutting off their plantations from the effects of the neglects or failures of those living above them. From the mouth of White River to the mouth of the Arkansas no levees have ever been built.

Those of the narrow strips of alluvion between the mouth of the Arkansas and the high ground near Gaines's Landing are very much broken, the river having eroded its banks and carried away the levee near Napoleon and in Cypress Bend.

III.—THE YAZOO BOTTOM.

From Memphis to Vicksburg, left bank; area, 6,800 square miles.

1. *De Soto County*.—The breaks in the levees of this county are not of material importance; no surveys were made of them. On the *Mississippi River front* the breaks amount to one and a half miles of levee, 5 feet high; on the *Horn Lake front*, to one mile of levee 8 feet high, and two miles 5 feet high. Contents of both fronts in cubic yards, 150,000; which, at 35 cents per cubic yard, will cost \$52,000.

2. *Tunica County*.—No surveys were made in this county, owing to the high stage of the river when the engineer party reached it. The

extent of the breaks has been measured by the county officers, and the result communicated to Colonel Abbot by the sheriff.

Location.	Length.	Height.	Remarks.
	Miles.	Feet.	
From north county-line to Commerce	1	9	460,000 cubic yards, at 35 cents per cubic yard, amounting to \$161,000.
From Commerce to Austin's	1 1-6	12	
From Austin's to Herbert's	2	8	
From Herbert's to O'Neill's	2	5	
From O'Neill's to Nail's Bayou, opposite Helena	1 1/2	7	
From Nail's Bayou to south county-line	2	8	

The crevasse-water through these breaks drains to the Coldwater through a region not so much opened as the counties below, and although considerable damage is done by the overflow thus caused, yet the comparative injury done was not, in my judgment, of sufficient magnitude to justify the temporary repair of all or of any of the breaks.

3. *Coahoma County.*—The breaks in the levees of this county were carefully surveyed. The first is the levee of the Yazoo Pass, which was cut, for military purposes, in two places in 1863—one in the pass where the levee was 38 feet high, the other about one mile below, where the levee is 18 feet high. This Yazoo Pass levee is 1,200 feet long, with an average height of 28 feet. It was built in 1858, after several unsuccessful attempts, across swampy ground, with quicksand, in places difficult to build upon. Owing to the great depth of the cuts in this levee, they let in a large volume of water and flood a great extent of cultivated land on the Mississippi River and on the Sunflower, Coldwater, and Tallahatchie Rivers. The repair of this levee I deemed to be one of the cases contemplated in your instructions.

Number of break.	Length.	Height.	Contents.	Price.	Amount.
	Feet.	Feet.	Cubic yards.	Cents.	
First	450	40 and 20	80,000	60	\$48,000
Second	420	21	50,000	60	30,000
Total			130,000		78,000

The points of repair are difficult of access, and the earth to fill the breaks must be hauled a considerable distance. Sixty cents per cubic yard is, perhaps, too low an estimate. The other breaks, excepting the break in the Lewis's Swamp levee, are :

Location.	Contents.	Price.	Amount.
	Cubic yards.	Cents.	
2. Roselle's, 2 miles above Friar's Point	37,000	40	\$14,800
3. Friar's Point	3,600	40	1,440
4. Miller's, near Friar's Point	28,000	40	11,200
5. Old Fort Royal Swamp	21,000	40	8,400
6. Fontaine's	10,000	40	4,000
7. Beard's	20,000	40	8,000
8. Mapleton's	20,000	40	8,000
Total	139,600		55,840

These breaks did not, in my judgment, come under the rule prescribed in your instructions for determining what breaks should be temporarily repaired.

The next break in order, and the last in Coahoma County, is—

9. The break in Lewis's Swamp levee, Sunflower landing. This break is two and a half miles long in a bend of the river, where the bank is caving rapidly, and has approached to within 2,000 feet of Hushpuckana Bayou. The upper part of the break is in Lewis's Swamp, which near the river bank has been much filled up by the deposit of the crevasse. The other part of the swamp is, however, very low.

The fall of the flood-water into Hushpuckana Bayou has washed out a deep gully from the bayou to within a short distance of the river-bank. The flood of this year may complete the connection of the gully with the river, and form a pass to the Hushpuckana, similar to that of the Yazoo Pass, and to the detriment of the country below.

The quantity of water that passed through this crevasse was so great as to fill the swamps in the vicinity nearly to the level of the river-surface, to flood the country to a considerable distance above, and to overflow a great extent of cultivable land below, in Bolivar County.

The repair of the levee at this point was, in my judgment, one of the cases contemplated in your instructions. To repair it by throwing up a levee from one end of the break to the other, passing near Hushpuckana Bayou, and through Lewis's Swamp, sufficiently far from the river to insure the levee from destruction until the river should wear into the Hushpuckana, was impracticable at the late season of the year at which my examination was made.

Foreseeing the difficulty and the delay likely to occur in constructing such a levee, and the temporary character of the protection it would give, the planters east of Hushpuckana Bayou set on foot a project to build a levee ten miles long up the east bank of Hushpuckana Bayou, beginning at some high grounds near Sunflower landing, and extending to Wimbush's. This would render their plantations in a measure secure. To perfect the security the two ends of their levee must be united to the levee on the river-bank. Five miles of this levee east of the Hushpuckana were under contract, and the work on it progressing well at the time of my examination of this locality in the latter part of December last.

Hushpuckana Bayou now serves merely as a drain to the downfall upon a narrow belt of land along its course of thirty miles, from its head at Old Port Royal to its mouth in Sunflower River. Formerly it was open to the river at Old Port Royal, and hence the high ground along its eastern bank.

By running a levee from the lower end of the Lewis's Swamp break, at Grant's plantation, across the Hushpuckana, to its east bank, protection would be given to the great body of cultivated land overflowed by this crevasse, since there was no doubt that the building of such a levee would insure the simultaneous extension to Wimbush's of the planters' levee already referred to. This project I approved, but its execution would still leave subject to overflow by the backwater of the crevasse some four or five thousand acres of cultivated land situated on the river above the break—comparatively a local matter.

To fix the location of the levee from Grant's to the east bank of the Hushpuckana, to ascertain how far it was practicable to protect the plantations above from backwater by throwing up a levee above the break, and running from the river-bank to the east bank of the Hushpuckana, and to ascertain the practicability and cost of building the levee through Lewis's Swamp, I directed certain surveys to be made. The result of these surveys is as follows:

Repairing the break by a levee through Lewis's Swamp, $3\frac{1}{2}$ miles long

contents, 190,000 cubic yards. But the located line, in crossing Lewis's Swamp, keeps so near the river-bank (in order to pass over the deposit of the crevasse) that the levee would soon fall into the river by the caving of the bank. Keeping 2,000 feet from the river, the quantity of embankment will be greatly increased, and will not be less than 400,000 cubic yards.

For the lower cross-levée:

From Grant's to Hushpuckana, contents.....	79,000
Crossing Hushpuckana.....	28,000
Total of lower cross-levée, cubic yards.....	107,000

Lewis's Swamp extends up the west bank of the Hushpuckana a considerable distance, and the first practicable point of crossing is some five or six miles above Sunflower landing, (twelve miles by the river,) at Robson's. From Robson's to Totten's, on the east bank of the Hushpuckana, is six miles; contents of levee, 435,000 cubic yards. This cross-levée would leave some 1,500 acres of cultivated land below it exposed to overflow from the backwater of Lewis's Swamp crevasse. It would also make dead water in the Hushpuckana Bayou, for six miles above, and turn the bayou at that distance into Harris's Bayou, which connects the Hushpuckana with the Sunflower. The levees required to protect the plantations from overflow, caused by this backing up of the rain-drainage of this part of Hushpuckana Bayou, would be small. It is evident that an expenditure like the preceding, for the end in view, was not contemplated by your instructions.

As a temporary protection to the region in question, the levee across Lewis's Swamp may be built during the ensuing fall. It is a legitimate expenditure under your instructions, and not disproportionate to the amount of saving of crops it will effect, although as part of a whole system it is not an economical application of means to an end.

Repair of Lewis's Swamp levee, by a line from Grant's west of the Hushpuckana and across Lewis's Swamp to the upper end of the break, contents 190,000 cubic yards, which, at 40 cents per yard, amounts to \$76,000; or, the inner line being chosen, contents 400,000 cubic yards, at 40 cents per cubic yard, amounts to \$160,000. As the Board of Levee Commissioners for the State of Mississippi has been re-organized, and the former chief engineer of the levees has been re-elected to that office, a project for the permanent protection of the region just treated of will demand their attention at an early day. The problem is a somewhat intricate one, and as the chief elements for the solution were collected by the surveys made under the direction of Col. H. L. Abbot, United States Engineers, in accordance with my instructions to him, I will state their principal results.

A levee from Grant's to the east bank of the Hushpuckana, and up the east bank of that bayou to its head, at Old Port Royal, on the Mississippi. Length of levee, eighteen miles; contents, exclusive of levee already constructed, 685,000 cubic yards. This will leave about 5,000 acres of cultivated land (the plantations below Wilkinson's landing) subject to overflow from backwater of the crevasse at Lewis's Swamp, to keep out which, back levees along these plantations will be required.

A levee from Grant's to the east bank of the Hushpuckana and up the east bank to Wimbush's; thence across the Hushpuckana to Wilkinson's landing, on the Mississippi. Length of levee, fifteen miles; contents, exclusive of levee already constructed, 611,000 cubic yards. This will leave 4,500 acres of cultivated land below it subject to the

backwater of the crevasse at Lewis's Swamp, to keep out which, back levees on those plantations must be constructed.

A levee from Grant's to the east bank of the Hushpuckana, and up the east bank to Totten's; thence across the Hushpuckana to Robson's, on the Mississippi. Length of levee, thirteen miles; contents, exclusive of levee already constructed, 637,000 cubic yards. This will leave some 1,500 acres of cultivated land below it exposed to overflow from the backwater of the Lewis's Swamp crevasse, to protect which back levees must be built. Small levees may be required on some of the plantations above, to keep out overflow from the backing up of the Hushpuckana, five or six miles, to Harris's Bayou, through which the drainage of the Hushpuckana must pass to the Sunflower.

The maps and profiles prepared from the surveys made under the direction of Colonel Abbot contain all the details of these projects. The contents of the levees have been computed with six feet thickness at the crown and slopes of three and two to one; the levee across the Hushpuckana, with a thickness of ten feet at the crown and slopes of four and two and a half to one.

4. *Bolivar County*.—1. The break at Prentiss.—A cut-off occurred at Napoleon on March 11, 1863, that turned the current of the river against the bank opposite, at Prentiss, which is being rapidly eroded; already some 8,000 feet of the levee have been carried off.

2. Three breaks in the bend below Prentiss, in Bolivar Bend, over a mile in length, where the levee is high and the banks caving. Two of these were cut by our forces in connection with military operations.

3. The break at Eastin's, Choctaw Bend, is over a mile in length where the levee is high.

These are the only breaks in Bolivar County. The crevasse-water through them floods an extensive district of cultivated land, over 100,000 acres in Bolivar and Washington Counties, on the Mississippi River, Deer Creek, and Bogue Falaya. Their repair, in my judgment, came under your rule.

It was not easy to decide how to repair the break at Prentiss. To solve the question, certain surveys were made. Their results are as follows:

The deep sloughs near Prentiss Point oblige a levee intended merely to close the break to be located so near the eroding bank that it would be carried away in a year or two. The contents of such a levee (with the repair of small breaks just below) are 132,000 cubic yards.

A permanent repair may be effected by a levee from Stark's to Prentiss along the east bank of Swan Lake; contents, 125,000 cubic yards. This leaves exposed to flood about 2,000 acres of cultivated land, and some 6,000 acres of wild land.

A third mode of repair is by a levee from Dr. Niblett's to Hiblard's, along the east bank of Vermillion Lake; contents, 135,000 cubic yards.

This leaves exposed to flood 4,000 acres cultivated land, and 11,000 acres uncleared land.

1. The Swan Lake route project is the best, and is recommended; contents, 125,000 cubic yards.

2. One of the cuts in the Bolivar Bend levee has been repaired by the planters. The repair of the others in the most temporary manner will require levees with contents of 35,000 cubic yards.

3. For repair of break at Eastin's; contents, 69,000 cubic yards.

5. *Washington County*.—The breaks in the levees of this county were repaired by the planters with the exception of that in Miller's Bend, which was under contract; but the available means of the planters did

not admit of its completion. The total amount of work required was 108,000 cubic yards, one-half of which was finished.

The crevasse-water through this break floods an extensive area of cultivated land. The completion of its repair will require a levee, with contents of 50,000 cubic yards.

6. *Issaquena County*.—The only break of importance in this county is at Colonel Christmas's, in a bend of the river about twelve miles below Providence. This break began in March, 1861, and extended down through Brown's and part of Coffield's plantations, being now more than two miles in length. The bank is caving rapidly throughout this extent. Its repair requires a levee with contents of 100,000 cubic yards. This crevasse floods some 8,000 acres of cultivated land below it, and, to a considerable extent, the plantations above it. It was a question with me whether it was of sufficient importance to come under the rule of your instructions, and no requisition for means to repair it was made by me. If an appropriation is asked for, it should probably be included with the estimate as above. This completes the levees of the Yazoo Bottom.

A Board of Levee Commissioners has been organized for the counties of Bolivar, Washington, and Issaquena, with authority to raise funds for repairing the levees by the issue of bonds to the amount of \$1,000,000, secured by a tax on land. The President of the Board, Colonel Field, was not sanguine that these bonds could be made available. The amount of work required for the temporary repair of all the breaks in the levees of the Yazoo bottom, the great alluvion of the State of Mississippi, is therefore :

County.	Contents.	Price.	Amount.
	<i>Cubic yds.</i>	<i>Cents.</i>	
De Sota	150,000	40	\$60,000
Tunica	400,000	40	184,000
Cashola	400,000	40 and 60	210,000
Bolivar	225,000	40	91,600
Washington	50,000	40	20,000
Issaquena	100,000	40	40,000
Total	1,449,000	.....	605,600

But repairs of such magnitude should be made permanent. Mr. Minor Merriwether, the chief engineer of the levees of the Mississippi, in his annual report of July 1, 1861, gave a detailed statement of the cost of repairing the levees at those points which required immediate attention. The total amounted to \$750,000. No repairs were put upon those levees during the war, and many of them are now broken. The cost of a cubic yard of embankment is at present double what it was in 1861, and the cost of the more permanent repair of the levees of the State of Mississippi may, therefore, be estimated at \$1,500,000.

For the temporary repair of the breaks in the levees at the most important points on the Yazoo front, I have estimated :

Location.	Contents.	Price.	Amount.
	<i>Cubic yds.</i>	<i>Cents.</i>	
1. For the Yazoo Pass levee	130,000	60	.....
2. For the Lewis's Swamp levee	190,000	40	.....
2. For the Bolivar County levee	225,000	40	.....
4. For Miller's Bend levee	50,000	40	.....
3. For Christmas's Bend levee	100,000	40	.....
Total	699,000	.....	\$305,000

IV.—THE TENSAS BOTTOM.

This alluvial district extends from Gaines's Landing to the mouth of Red River; its area is 4,000 square miles.

The levees of the narrow strips of alluvial land between Gaines's Landing and the boundary-line of Arkansas and Louisiana are in very bad condition; the sum of the lengths of the breaks, nine in number, amounting to six miles, mostly of high levee. The levee is, besides, much worn in many places.

In the bend above Columbia the bank is caving badly. There are two breaks here at Bellevue and Pastoria.

Localities.	Length.		Height.	Contents.
	Miles.	Feet.		
1. Bellevue, (Session's)	1	12		45,000
2. Pastoria, (Session's)	1	15		150,000
3. Ford's Belle Point, (American cut-off)	1	12		135,000
4. Mathew's Bend levee, (cut off by the enemy to flood the country below and embarrass General Grant's movements)	1	20		130,000
5. Polk's, (above Grand Lake)	1	12		50,000
6. Below Grand Lake	1	8		10,000
7. Flournoy's	1	7		10,000
8. Ballard's	1	7		30,000
9. Near State boundary-line	1	12		34,000
Total				564,000

Besides the local importance of these breaks, the crevasse water through them floods the land below on the Tensas. A part of the flood through the breaks above Columbia passes into the Bœuf, and does not reach the Tensas bottom. Their importance in connection with that bottom is not as great relatively as that of the breaks below Columbia.

Adopting Ford's, Polk's, and the two larger near the State boundary-line for temporary repair, we have three and a quarter miles of levee—contents, 259,000 cubic yards. The remaining breaks must be left to the State of Arkansas, or to Chicot County, or to the planters.

The State of Louisiana undertook the repair of its levees last winter, and for that purpose divided her alluvion into two parts—the first division extending from the Gulf to the mouth of Red River the second comprising all alluvial land above Red River.

Mr. J. A. d'Hémécourt was appointed chief engineer of the first, and Mr. J. A. Porter chief engineer of the second division.

The principal breaks in the levees of the second division are those now to be named; they will complete the list of breaks in the Tensas bottom.

1. At Ashton's Landing, near the northern boundary of Louisiana, there are three breaks in the levee, where it was cut by our troops in 1863 for military purposes. The sum of the breaks amounts to 1,200 yards of levee, exceeding 14 feet high. Contents, 100,000 cubic yards.

2. At Providence the levee was also cut by our troops in 1863 for military purposes. The closure of this break has probably been completed by the State or county. It was not extensive.

3. The levee at Bass's, four miles below Providence, which is 12 feet high, has a break two miles in length. (The volume of water that passes through this break is enormous.) Contents of the repair levee, 200,000 cubic yards.

4. There is a small break at Haws Harris's plantation, at the bound-

ary-line of Carroll Parish. As a permanent protection at this point, it is proposed by the State engineer to run a levee across Terrapin Neck, one and a half miles long. Contents, 100,000 cubic yards. The river made a cut-off here this spring.

5. At Young's Point, opposite the mouth of the Yazoo River, the levee, over 8 feet high, was broken half a mile in length. It has been repaired by the State engineer.

6. The breaks in Milliken's Bend, which were small, have also been repaired by the State engineer.

7. Opposite Vicksburg, where our troops endeavored to make a cut-off, the breaks amount to 450 yards. The length of the inclosing levee which the State engineer is building is 4,400 feet; height, 10 feet. Contents, 96,000 cubic yards.

8. At Brown and Johnson's, six miles below Vicksburg, the break in a low, caving, and gullied bank is 1,600 feet long. The inclosing repair levee of the State is to be 7,000 feet long, with an average height of 13 feet; one-half of this has been built by the State. Contents of the remaining half, 75,000 cubic yards.

9. In Dimond Island Bend, the breaks, one-half mile in length, have been repaired by the State engineer; a new levee will be built, one and a half miles long and 9 feet high. Contents, 100,000 cubic yards.

10. At Point Pleasant, on Buckner's place, a break 3,200 feet long in a caving bank, requires a new levee two miles long, 9 feet high. Contents, 105,000 cubic yards. No work was done here by the State engineer at the close of March, 1866.

11. At Alligator Bayou, five miles above Grand Gulf, or two miles above Hard Times Landing, there are breaks 300 yards long. The repair levees will not be less than 1,000 yards long, and 12 or 15 feet high. Contents, 60,000 cubic yards. Not much progress was made upon the repair levee at the close of March.

12. At Kemp's, ten miles above Rodney, an extensive break in a caving bank requires a new levee over two miles long, 8 feet high. Contents, 100,000 cubic yards. This levee was probably finished by the State engineer by the last of March.

13. The breaks in Concordia Parish were probably closed by the State engineer; they were not very important, and amount to 100,000 cubic yards.

This completes the list of breaks in the levees of the Tensas bottom. The break in the Bass levee is by far the most important of all. The crevasse water through it floods nearly as much land as that of all the chief breaks below it.

The cotton-crop of 1860, of the four parishes of Louisiana situated in this bottom, was about 240,000 bales. The points selected for temporary repair under the rule, are:

Locality.	Contents.	Price.	Amount.
	<i>Cubic yards.</i>	<i>Cents.</i>	
1. The Ashton Landing breaks.....	100, 000	40	
2. The Bass Levee break.....	200, 000	40	
3. The Brown and Johnson break.....	75, 000	40	
4. The Point Pleasant break.....	105, 000	40	
Total.....	480, 000	40	
This added to breaks above State line.....	259, 000	40	
	739, 000	40	
Gives for total of Tensas bottom.....			\$295, 600

V.—THE DELTA OF THE MISSISSIPPI.

This designation is given to the alluvion below the mouth of Red River, because at that point the Mississippi River begins to divide, throwing off the Atchafalaya, which finally empties into the Gulf.

The breaks in the levee between the mouth of Red River and the Gulf are so numerous, that I shall only mention in detail those great breaks, the volume of water pouring through which, in high-water, inundates immense tracts of cultivated land, and the repair of which is therefore recommended.

	Cubic yards.
1. At Morganza, where the high levee is broken for the space of nearly a mile, requiring for repair a levee 7,400 feet long, over 12 feet high; contents.....	200,000
2. At Scott's, five miles above Bayou Sara, where a break of over half a mile in a caving bank requires for repair a 9-foot level over a mile long; contents.....	94,000
3. At Robertson's and Chinn's, ten miles above Baton Rouge, where a break of two miles in a levee 13 feet high requires a new levee, with contents of.....	250,000
Total for Delta of the Mississippi.....	544,000

Which, at 40 cents per cubic yard, is \$217,600.

There were three other points where the breaks were of magnitude—the Parish levee at Red River, the Grand levee, and Hereford's levee—the repair of which will require some 240,000 cubic yards, but they are of less importance than those adopted.

Besides the three adopted, there are fifty-six breaks in the levees below the mouth of Red River, the repair of which will require 1,020,000 cubic yards of leveeing.

The following is a recapitulation of the repairs recommended by me to be made under your instructions of December 11th last:

	Contents.	Price.	Amount.
<i>The Yazoo Bottom.</i>			
	<i>Cubic yards.</i>	<i>Cents.</i>	
1. The Yazoo Pass levee.....	130,000	60	.....
2. The Lewis's Swamp levee.....	190,000	40	.....
3. The Bolivar County levees.....	299,000	40	.....
4. The Miller's Bend levee.....	50,000	40	.....
5. The Christmas.....	100,000	40	.....
Total.....	699,000	.....	\$305,600
<i>The Tensas Bottom.</i>			
1. Ford's Belle Point levee, Arkansas.....	135,000	40	.....
2. Polk's Grand Lake levee, Arkansas.....	30,000	40	.....
3. Ballard's levee, Arkansas.....	30,000	40	.....
4. Near the State boundary, Arkansas.....	34,000	40	.....
5. The Ashton Landing levee.....	100,000	40	.....
6. The Bass levee, Louisiana.....	200,000	40	.....
7. The Brown and Johnson levee, Louisiana.....	75,000	40	.....
8. The Point Pleasant levee, Louisiana.....	105,000	40	.....
Total.....	739,000	.....	295,600
<i>The Delta of the Mississippi.</i>			
1. The Morganza levee.....	200,000	40	.....
2. The Scott levee.....	94,000	40	.....
3. The Robertson and Chinn levee.....	250,000	40	.....
Total.....	554,000	40	217,600

RECAPITULATION.

	Cubic yards.	Amount.
1. The Yazoo Bottom	699,000	\$305,000
2. The Tensas Bottom	739,000	295,000
3. The Delta of the Mississippi	544,000	217,000
Total	1,982,000	817,000

The cotton-crop of 1860 of that portion of the alluvial region above the mouth of Red River where it is proposed to make these repairs must have exceeded 600,000 bales, a tax of 1 per cent. per pound on which would amount to \$2,700,000.

The value of the crop at present prices is \$108,000,000.

The sugar-crop of 1860 of that part of the alluvial region below the mouth of Red River where it is proposed to make these repairs amounted to 241,000 hogsheads of sugar and 317,000 barrels of molasses, the value of which, at present prices, is \$50,000,000.

The foregoing statement presents a tolerably fair exhibition of the condition of the levees of the Mississippi River. Those of the St. Francis Bottom have, from their dilapidated state, seemed to be excluded from consideration. The most important breaks in those of the other three great alluvial districts have been recommended for repair.

The complete and permanent repair of all the levees of the river would require—

1. For the State of Arkansas, 3,000,000 cubic yards	\$1,200,000
2. For the State of Mississippi	1,500,000
3. For the State of Louisiana, 3,000,000 cubic yards	1,200,000
Total for permanent repair of all the levees	3,900,000

The repairs put upon the levees of the State of Louisiana during the past year amounted, on the 1st of March, to 700,000 cubic yards.

Before concluding this subject, I desire to ask attention to the recommendation on pages 417 to 421 of that part of the report of myself and Colonel Abbot on the Mississippi River which treats of the protection of the alluvial region against overflow.

It is there stated, as the result of the careful investigation the subject had received, that the only method of protection against inundation that could be resorted to with success was the levee system, but that the levees as then constructed were not high enough by several feet. The additional heights that should be given at different points in the course of the river are there pointed out.

It is further stated that if there were no levees whatever the cost of constructing them of such height and dimensions as would give complete protection against inundation to the whole alluvial region would amount to about \$26,000,000.

That to bring the levees then standing to this perfection, supposing them to be properly located, would cost \$17,000,000.

The area thus protected amounts to 31,700 square miles, of which a mere narrow strip along the banks of the river and along a few bayous has been opened for cultivation.

Of this area 12,300 square miles is below Red River, and belongs to the sugar region. Under a proper system of protection and drainage one-third of it may be eventually opened and cultivated, or 2,500,000 acres.

There are now under cultivation in this region about 1,000,000 acres.

Of the remaining 19,400 square miles, perhaps 3,000 square miles may be north of the cotton-growing region, leaving some 16,000 square miles within that region of the most fertile alluvion, two-thirds of which may

be finally rendered cultivable under a proper system of leveeing and draining. This would give 7,000,000 acres of cultivated land, capable of growing a bale of cotton to the acre, or about double the whole cotton-crop of the United States in 1860.

The levees constructed under such a system would not, where greatest, exceed in magnitude those on the right branch of the Rhine below Arnheim, which protect the most fertile part of Holland. These levees are exposed at high-water to as strong a current as that of the Mississippi in flood, and also to the destructive effects of ice. But the occurrence of crevasses such as take place with every great flood of the Mississippi are there unknown. Should they happen, the ruin of a large part of the most productive portion of Holland would follow, as extensive tracts protected by the levees are lower than the surface of the sea, and their reclamation from overflow could only be effected by a drainage similar to that which has been applied to the lake of Harlem. The supervision, watching, and repair of these levees is costly, but effective and remunerative. The levees of the Mississippi, as now existing, are trifling compared to the interests they protect, and to the levees of the delta-rivers of Europe—the Po, the Rhine, and the Vistula.

Some indication of the great wealth that would flow from the establishment of a proper levee-system is given in what precedes; such a system will probably be introduced gradually, and, as experience proves to those who must pay for it, that it is more and more necessary.

It should comprise a great levee on each bank, intended for the general protection of the whole interior alluvion, and set, wherever practicable beyond the limit of the bends of the river, so as to be safe against the effects of caving banks—the great cause of the destruction of levees. This is practicable in the upper course of the river, where the erosion of the banks is greatest.

Next in order after the great levee is that for the protection of the plantations along the river-bank outside the great levee, but where the interests concerned are of so great magnitude that they may still be classed as general. On some portions of the river these two classes must unite and become one. Connected with these two classes are guard-levees.

Third in order are those where the interests protected are merely local, although the protection may include many thousand acres. The proper establishment and maintenance of the first order of levees requires some authority entirely beyond the influence of local interests. The second class is of a mixed character, in the establishment and maintenance of which the general and local interests should usually be united. The third class should be left entirely to local or personal means and authority.

Under the acts of Congress directing "the topographical and hydrographical survey of the delta of the Mississippi River, with such investigations as might lead to determine the most practicable plan for securing it from inundation and the best mode of deepening the channels at the mouths of the river," extended surveys and investigations were carried on under my direction during several years, and the report upon the results, prepared by myself and Colonel Abbot, was submitted by me to the Bureau of Topographical Engineers in August, 1861. A few copies of the report were printed by the War Department, and distributed to officers of the Army and to the public libraries and learned societies of this country and of Europe.

In my recent visit to the Mississippi River I found precisely the same degree of ignorance and the same false views concerning the actual condition of the river and all the methods of protection against inundation

that prevailed in 1851, when the investigations directed by Congress were set on foot. No copies of the report have been distributed in that region, nor are there any on hand for that purpose.

It is essential to the successful introduction of proper methods of protection that the information contained in the report mentioned should be made available to the people living in the alluvial region, and I beg leave to suggest the printing by Congress, or by the War Department, of a large edition of the report, and its liberal distribution among them.

Under your instructions of December 4, 1865, I left Washington on the 17th of December to examine and repair the levees, and having completed a preliminary examination about the 8th of January, 1866, made requisition upon General Canby for the means of repairing the ten principal breaks. These means, however, it was not in the power of General Canby or the War Department to furnish, and my duties were limited to such surveys and examinations as the subject appeared to me to require.

I assigned Major and Brevet Colonel H. L. Abbot, United States Engineers, to the charge of that part of the river between the head of the alluvion and Vicksburg, excluding the State of Louisiana, and Captain and Brevet Major J. B. Wheeler, United States Engineers, to that portion of the river-bank in the State of Louisiana.

Such surveys as were necessary in Louisiana, together with the requisite plats, had, for the most part, been made by the State engineers, but extended surveys and measurements were necessary on the Yazoo bottom, and were made under the direction of Colonel Abbot. The results are presented by him in a valuable report, accompanied by six maps and eleven sheets of profiles.

I take leave to acknowledge the valuable services rendered by Colonel Abbot, and the efficient assistance afforded me by Major Wheeler. Lieutenant Mackenzie, United States Engineers, was assigned to duty with Colonel Abbot, who mentions his zealous labors in terms of commendation.

An explanatory diagram is annexed.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Major-General Volunteers.

Hon. EDWIN M. STANTON,
Secretary of War.

Report of Col. H. L. Abbot.

MAY 2, 1866.

GENERAL: I have the honor to submit the following report upon operations conducted under your instructions upon the Mississippi levees during the present season.

I received paragraph 3, Special Order No. 634, Adjutant-General Office, dated Washington, December 12, 1865, directing me to report to you for temporary duty at Washington, on its date, and at once left Willet's Point to comply with its provisions. I reported on December 14, returned the same day to turn over my engineer property at New York, and finally joined you at Memphis, Tenn., on December 24. Two days after, by your letter of that date, I was placed in charge of the examinations and repairs as far down as Vicksburg.

I accompanied you on the steamer *Flora* during your personal examination of the breaks in the levees as far down as Vicksburg, arriving there on January 2, 1866. I here instructed Capt. H. A. Pattison to procure an assistant engineer, and to return on the *Flora* to survey and stake out the levee at certain localities where work was most needed, and proceeded myself to New Orleans to ascertain what means you would be able to furnish for the work. I there remained until January 27, when, in accordance with your letter of that date, I proceeded up the river to Memphis, to prepare to supervise the construction of the levees under contracts then entered into by yourself. I employed an assistant engineer and rodman in New Orleans, and left them to supervise the work in Bolivar Bend, which I designed to place under charge of Bvt. Capt. A. Mackenzie,

who reported to me by your order at this time. I reached Memphis on February 1, and had engaged an engineer for the Ashton levee, when I received your telegram of February 1, directing me to await orders in Memphis. This I did until February 6, when, having received permission to do so, I started for the steamer *Flora*, leaving my engineer, Mr. Gloster, to bring me your final orders, which, dated February 20, reached me on February 24, directing me to discontinue all preparations to repair the levees, but to continue the examinations. I accordingly at once broke up the party at Bolivar Bend. Mr. Gloster had joined the *Flora* on February 22, thus giving me two engineers and two assistants, with the necessary rodmen, &c. With this party I continued the surveys actively until March 15, when the river prevented further work. I started for Memphis, stopping at all important localities to make inquiries, and arrived on March 20. I found Captain Mackenzie awaiting me with funds, and at once discharged the *Flora* and all the party not required to complete the maps and estimates.

I transmit the following named maps and profiles, the results of the surveys :

1 sheet, localities of breaks in Bolivar and Choctaw Bends. Scales 1: 6000, 1: 2400, 1: 1200.

1 sheet, Indian Point, Bolivar County, Mississippi. Scale 1: 12,000.

3 sheets, breaks in Coahoma County, Mississippi. Scale 1: 12,000.

1 sheet, map and profile of wash from Sunflower Landing to Hushpuckana. Scale 1: 2000.

Profile, breaks in Bolivar and Choctaw Bends, showing located levee.

Profile, Nibblet's to Hibbard's by river.

Profile, Nibblet's to Hibbard's by Vermillion Lake route.

Profile, Starke's to Prentiss by Swan Lake route.

Profile, trial lines near Prentiss.

Profile, Grant's to Old Port Royal, east of Hushpuckana.

Profile, Grant's to old levee west of Hushpuckana.

Profile, Robson's Landing to Delta, along old levee.

Profile, Robson's to Totten's through Swamp, to connect with levee east of Hushpuckana.

Profile, McCloud to Wimbush's through Swamp, to connect with levee east of Hushpuckana.

Profile, trial lines from Grant's with sections of bayous.

These maps and profiles show the results of 86.7 miles of compass and 82.7 miles of level surveys, and are in such detail as to render no long written description of the routes necessary. The following are the levee estimates. For convenience of comparison the width of crown is assumed at 6 feet, with slopes of 3 to 1 and 2 to 1, except for crossing bayou Hushpuckana, where the crown is 10 feet, with slopes of 4 to 1 and 2½ to 1.

BOLIVAR AND CHOCTAW BENDS.

Eastin levee.—Levee about 8 feet high and 1,500 feet back from river; cubic contents, 69,000 yards. Location through old field with favorable soil, except one slough where woods extend about 400 feet.

Vick and Yergar.—Two hoops, one 27,000 cubic yards, the other 8,000 cubic yards. Average height of levee, 8 feet; distance back from river, about 300 feet; location through old field. It is to be remarked that the entire levee in Bolivar Bend is very near the river, and that the banks are caving so rapidly as to render it certain that a new levee must soon be built. The above locations are only designed for this crop. Next year quite a different line will be needful.

INDIAN POINT LEVEE.

A cut-off occurred at Napoleon on March 11, 1863. The result has been to form a large sand-bar in front of Napoleon and to rapidly erode the opposite point. To decide the proper location for a levee to close this break, extensive surveys have been made. There are three principal routes:

1st. River bank.—This can only serve a very temporary purpose, for the location shown on the map is as far from the river as it can be made without crossing deep sloughs, and the levee, if built on it, must soon cave into the river. Between January 22 and February 26, '66, 400 feet caved off from the exposed end of the old levee, at the upper end of the break. The estimates are as follows:

	Cubic yards.
Hoop for the Great cave	113,000
Wildwood break	10,000
Smaller breaks	8,700
Total	131,700

The soil throughout is very favorable for working.

2d. Vermillion Lake route.—This route is entirely safe, and a small private levee was built upon it which was badly located on the very edge of the lake, and is now much

washed. But little of it could be made useful. The route lies through old fields and deadened woods. The estimates are as follows:

	Cubic yards.
Levee, (entirely new).....	145,000
Deduct for old levee.....	10,000
Required, say.....	135,000

3d. Swan Lake route.—This route is very favorable and saves about half of the 4,000 acres of cleared land and 11,000 acres of wild land thrown out by the Vermillion Lake route. The objection to it lies solely in the danger of its junction with the old levee at Prentiss caving into the river—a matter not easily decided at present. About a mile of the route lies through old field, the rest through cane and forest. The soil is favorable. Three northern terminal locations were surveyed, upon which the estimates are the following: (See map.)

	Cubic yards.
Route farthest from river.....	125,000
Intermediate route.....	115,200
Route nearest to river.....	119,200

The foregoing cover all the breaks which, under your instructions, I felt called upon to survey in Bolivar County.

The first serious break from the southern boundary of Coahoma County is that at Lewis Swamps, just above Grant's, on the old Crenshaw place. This offers peculiar difficulties. The river has been, and now is, very rapidly caving away its banks in this bend. It has approached so near to Bayou Hushpuckana as to force the levee either to cross the bayou or to pass through a low and difficult part of Lewis Swamps at great cost, and with the certainty of ultimately and at no very distant date caving into the river. I believe it to be inevitable in a few years, if not at present, that the levee cross the bayou. When this is done, it can only return to the river near Wilkinson's Landing, or strike old river near Old Port Royal, unless a better route to Robson's can be discovered than that surveyed by me. Anticipating this necessity, certain gentlemen have built nearly five miles of levee on the east bank of Hushpuckana. The Robson route throws out 1,500 acres of arable land; the Wilkinson route 4,500 acres arable land now cleared.

The maps show the character of the different proposed routes. That west of Hushpuckana passes through old deadened woods, cane, and low, unstable swamp. That east of the bayou chiefly through old field and deadened woods, with some forest and heavy cane near its northern extremity.

The matter of draining Hushpuckana is quite a serious one. If it be crossed on the located line, a deep wash from Sunflower Landing back to the bayou might be enlarged and extended quite to the river. This would, however, cause a general overflow of the low swamp when the Mississippi passed much above mid-stage. For on February 6, when the river stood 9 feet below high-water 1865, the water of the bayou was 19 feet below the level of the river. To cross the bayou again below Wimbush's would certainly cause an extensive rain-water lake, which, being dammed up by the levee, would render an extravagant cross-section through the low lands necessary. At Wimbush's, Harris Bayou would afford channel-way, perhaps, with some clearing out and enlarging, for the surplus water to Sunflower River. The Old Port Royal route avoids this difficulty by not recrossing the bayou.

The following are the estimates upon the several routes surveyed, allowing 60,000 cubic yards for the levee already built east of Hushpuckana:

	Cubic yards.
Route west of Hushpuckana.....	190,000
Route east of Hushpuckana to Robson's.....	637,000
Route east of Hushpuckana to Wilkinson's Landing.....	611,000
Route east of Hushpuckana to Old Port Royal.....	685,000

Should it be deemed advisable to incur the periodical flooding of the Lewis Swamp region by Mississippi water backed up through the artificial mouth at Sunflower Landing, rather than by the rain-water, the expense of any of the last three routes must be increased by the cost of excavating 10,000 cubic yards to open this wash to the river. (See special map and section of this wash.) If the break in the levee is not soon closed, it is very probable that this work will be done by the river itself, and a pass like the Yazoo Pass be formed, to the great detriment of the region below. Indeed, this threatened calamity is so imminent that the plan of operations at the locality calls for immediate decision and action.

Above Lewis Swamp to Delta the breaks require no unusually extensive work. The following list is complete, and the amounts from actual survey:

	Cubic yards.
Crevasse at Mapleton's.....	20,000
Crevasse at Beard's.....	20,000
Crevasse at Fontaine's.....	10,000

	Cubic yards.
Crevasse at Old Port Royal	21,000
Crevasse at Miller's	28,000
Crevasse at Friar's Point	3,600
Crevasse at Rozelle's	37,000
Total	139,600

The following was the condition of the Yazoo Pass levee on December 28, 1865, the date of its examination :

Two cuts had been made by the Navy, one at each end of the big levee, which, with these exceptions, was in good order. The north cut was 220 feet long, 40 feet deep, and 230 feet long, 20 feet deep, say 80,000 cubic yards. The south cut was 420 feet long, 21 feet deep, say 50,000 cubic yards. Total, 130,000 cubic yards.

The facilities for obtaining dirt were poor, an average haul of 200 yards being required. This fact and the great depth of the northern break (and the consequent liability to damage from the sudden rise of the Mississippi during the progress of the work) will render the cost of repairing this levee greater than the average. In the estimates the following are the dimensions : Crown, ten feet ; slopes, 5 to 1 and 2½ to 1.

The above is a summary of all the actual surveys made by my parties. For full details, attention is respectfully invited to the accompanying maps and profiles.

Every effort was made to obtain correct information as to the condition of the levees where actual surveys were not made. The following exhibits the results, beginning at Vicksburg and passing up the river to the Ohio on the left bank, and returning on the right bank.

Issaquena County was considered to be excluded from the plan of operations, because its vicinity to the mouth of Yazoo River would prevent any extensive districts being benefited by repairs. One large break at Christmas's plantation, below Greenville, was visited by you in person. Other breaks exist, but no details were learned by me.

Washington County is fortunate in possessing planters having the energy and ability to aid themselves. An official document from the board of levee commissioners states, under date of January 25, 1866, "that the only levee in said county which is not now in a condition to give the planters assurance of the necessary protection, is the one in Miller's Bend"—estimated cost \$41,000, at 38 cents per cubic yard, the contract price.

In Bolivar and Coahoma Counties, as already stated, all the breaks were surveyed and have been already reported upon.

In Tunica County no surveys were made, owing to the high stage of the river when the party had reached the vicinity. The following statement is from an official letter addressed to me by the sheriff and the president of the board of police, showing the breaks :

From south county line to Nail's Bayou, (opposite Helena) . . .	2 miles of 8-foot levee.
From Nail's Bayou to Mrs. O'Neal's	1½ miles of 7-foot levee.
From O'Neal's to Harbert	2 miles of 5-foot levee.
From Harbert to Austin	2 miles of 8-foot levee.
From Austin to Commerce	0½ mile of 12-foot levee.
From Commerce to north county line	1 mile of 9-foot levee.

Total, correct in length, approximate in height..... 8½ miles.

In De Soto County no official statement could be obtained, but the following is the estimate of the gentlemen to whom I was referred as best informed in the county :

On Mississippi River front, one and a half miles 5-foot levee, occasionally 8 feet.

On Horn Lake front, one mile 8-foot levee ; two miles 5-foot levee.

This completes all the levee estimates on this bank, as the high land approaches so near the river that no levee system has ever been attempted above the Memphis bluff.

On the right bank, from Cape Girardeau to the Missouri State line, no very definite information was obtained, but as a portion of the levee fund is reported to remain unexpended, and as the levees themselves are said to be in a tolerable condition, and especially as nearly all the overflow returns from points above at New Madrid, nothing would seem to be required to be done by the General Government in this section.

From the State line to Osceola the only break reported was a small one at Bearfield Point. From Osceola to Memphis the following list is approximately exact, and is complete :

- 1st. Mrs. McGavock, near Osceola, a small break.
- 2d. Le Ma's place, above Island 34, unleveed gap 30 yards long, 20 feet deep.
- 3d. Nodina place, bend of Island 34, unleveed gap 30 yards long, 30 feet deep.
- 4th. Morgans & Craighead's, below foot of Island 34, breaks 440 yards long, 5 feet deep.
- 5th. Pecan Point, foot of Island 35, unleveed bayou (Barney's) 30 yards long, 30 feet deep.
- 6th. Above Shawnee Village, high land in bend of Island 37, 3,500 yards long, 12 to 15 feet deep.

7th. Below Shawnee Village, high land in bend of Island 37, 5,300 yards long, 10 to 12 feet deep.

8th. Three miles below Shawnee Village, (Morris's Pacific place,) thirty miles above Memphis, 70 yards long, 40 feet deep.

9th. Fogleman's, seven miles above Memphis, 300 yards long, 12 to 15 feet deep.

In Mississippi County, Arkansas, which extends from the Missouri line to a point about thirty-five miles above Memphis by river, a tax has very recently been levied of 10 cents per acre for levee purposes.

There is also a project to construct a railroad from the bank of the Mississippi opposite Memphis upon ridges which run nearly parallel to the river, and about eight miles from its general course up to the vicinity of Osceola, and thence diverge to the westward across the bottom lands to connect with the Iron Mountain Railroad of Missouri. The road-bed is to be made to serve as a levee, which will thus reclaim immense tracts of valuable land. Its location will insure it against caving, the great cause of failure heretofore in reclaiming this region.

Below Memphis the condition of the St. Francis front levee is very bad. Constructed in the first instance much too near the river, which in this part of its course is rapidly eroding its banks, (in Council Bend 1.5 miles in forty years,) subject near St. Francis River to overflow from the rear, which has even washed large parts of it into the river, and, above all, neglected for the past five or six years, the levee may be considered as practically worthless. To repair it would be more expensive than to construct a proper levee on a judiciously selected location. Indeed, for the lower part of the St. Francis front it is useless to attempt any levee system until the country above is reclaimed, owing to the destructive effect of the water returning to the river over the banks. In fine, then, it may be considered that for thirty miles below Memphis about one-half of the distance is leveed and the rest open, and chiefly in the bends, which would require much labor to levee, so as to connect the fragment still standing open near the points. From the end of this distance to the St. Francis River the bottom lands are open to the river.

Between St. Francis River and Helena, a salient point of the levee has caved into the river. This is, however, a mere local matter. The bank at the mouth of this tributary is very rapidly caving.

Between Helena and Old Town Ridge the following information is exact as to the breaks, being the result of measurements made by the levee commissioners: first break, 56,000 cubic yards; second and third breaks, 2,000 cubic yards; fourth break, 40,000 cubic yards; fifth break, 50,000 cubic yards. The repair of these breaks would reclaim a valuable district lying between the Mississippi and Crowley's Ridge and its spur, Old Town Ridge. It is, however, a local matter, no great area being affected.

From Old Town Ridge to Carson's Landing, near Islands 67-8, there are several breaks reported, the one at Luna place originating in a caving bank, admitting a good deal of water. Thence to Laconia the levee is good; distance fifteen miles. The Luna bank is half a mile long; levee 12 feet high.

At Laconia the planters have displayed a good deal of energy. They have repaired the State levee thence to Bob's Bayou, which enters the Mississippi two miles below Island 71, a distance of seven miles. They have connected these termini by a rear levee about eleven miles long, thus reclaiming about 15,000 acres of arable land. They have graded the levee three feet above high-water. This district exhibits every sign of activity, fences being repaired and land generally plowed.

The amount of work done has been 45,058 cubic yards on the State levee, and 114,500 cubic yards on the rear levee, price 2 pounds of next crop of cotton per yard, estimated actual cost to contractors 35 to 37 cents per yard.

From Bob's Bayou to Napoleon no levees have ever been built.

From Napoleon to the northern boundary of Louisiana the following facts were collected by Bvt. Capt. A. McKenzie, United States Engineers, during a special trip made for the purpose:

Just below Napoleon the river has badly eroded its banks, and the levee has caved into it.

In Cypress Bend three to four miles have caved into the river. From Eunice to Gaines's Landing the levee is good.

From Campbell's to Wallworth's one mile of 15-foot levee must be constructed. This break is just below Gaines's Landing.

On the Walworth place, opposite Island 82, 50 yards of 7-foot levee is required.

Just below, on Bellevue place, (Dan. Sessions,) there is a break of one-half mile of 12-foot levee.

Just below, on Pastoria place, one mile of 15-foot levee has caved into the river.

The river is caving badly from the foot of Island 82 to the last-named break, and extensive repairs are required. From this break to Columbia the river is not caving.

The next break is at the American Bend Cut-off, (Belle Point,) where one and a half miles of 12-foot levee have caved into the river. This break is known as "Ford's." From this point the breaks are frequent.

The next is at head of Matthew's Bend; on Gosey's and Ross's fronts, where 100 yards of 12-foot levee are required.

In Matthew's Bend, a fine levee, which cost \$80,000 in gold in 1860, was cut for military purposes, there is now a gap 300 yards long, and a 17-foot levee required. (Another authority, 350 yards of 18 to 21 foot levee.)

One and a half miles below, on Polk's Point, a mile of 12-foot levee (also cut) is needed. Portions of the old levee are still in existence.

Just below Grand Lake is a break 300 yards long and 12 feet deep. (Another authority, one-fourth of a mile long, and 8 feet deep.) This resulted from a cut.

On Flourney front a 7-foot levee has caved for one-fourth of a mile, and half a mile further down, on Ballard place, three-fourths of a mile of 7-foot levee is required.

Within about a mile of the Louisiana State line there are three small breaks—aggregate about 500 yards of 12-foot levee. (Another authority, 600 yards.)

In Louisiana there are three breaks near Ashton, at the State boundary; the first 850 feet long; the second 1,430 feet long; the third similar to the second. At all of them a 13-foot levee is required. They were under contract by the State, but I doubt if they were completed in season.

The next was at Providence, where the Navy cut a canal back to the lake. This levee was, I suppose, finished before the river rose, as when I last saw it it was well advanced.

The next break was at Bass's plantation, above Point Lookout, and was a large and serious one, damaging a great extent of country. The next one was at the Davis plantation, near foot of Island 97; the next at Harris's, above Terrapin Neck; the next at Duckport, near foot of Paw-Paw Island. Thence the levee was complete to the great Brown and Johnson break, just below Vicksburg.

All the levees in Louisiana were under State contract, and, knowing that you had received full information concerning them from Major Porter, State engineer, I made no special effort to collect facts relating to those of them lying within my district.

I made every effort to obtain all possible information relative to the river since the termination of the Mississippi-delta survey in 1861. The only high-water years were 1862 and 1865. The following table exhibits the data collected respecting these floods, as well as that of 1859. The same system is adopted as in the table on page 170 of the delta report; i. e., the plane of reference is the flood-level of 1858, the sign + indicating that the water rose above, and the sign — that the water failed to attain, the level of that great flood. Asterisks denote possible uncertainty, although none is believed to exist. It is to be regretted that the war prevented the preservation of exact information as to dates and sources of these two floods.

Locality.	1859.	1862.	1865.	Remarks.
Cairo	-3.1	+1.2	.....	The following record at Cairo is from Mr. Aug. F. Taylor, of the Cairo City Company: High-water May 7, 1859, was -3.1; high-water April 24 and 25, 1861, was -6.4; high-water March 17 and 18, 1865, was -1.6; and on March 20, 1866, (highest of year to date,) was -8.3. Low-water on November 10 to 17, 1859, was -44.2; on October 12, 1860, was -46.0; and on December 4, 1865, was -42.9. The date of high-water 1862 was May 2.
Memphis .....	.....	+0.6	-0.5	
Head Cat Island .....	.....	+0.7*	-0.2*	
Foot Cat Island	-0.3*	+0.7*	-0.3*	
Head Walnut Bend	-2.0*	+1.1*	-0.4*	
Helena	-1.0*	+1.8	-0.2	
Friar's Point	-0.7	+1.5	0.0	
Wilkinson's Landing, Island 63	+0.1	+0.9	0.0	
Sunflower Landing, Island 66	+0.3	+0.8	-0.7	High-water 1860 was -1.0.
Napoleon .....	.....	+2.1	+1.75	
Prentiss .....	.....	.....	+2.0	
Bolivar Bend .....	.....	.....	.....	High-water 1865 was 0.7* feet below high-water 1862.
Choctaw Bend .....	.....	.....	.....	High-water 1865 was 0.5* feet below high-water 1862.
Providence .....	.....	.....	-1.0*	
Vicksburg .....	.....	+2.2	-0.5	Date, April 27, 1862.
Red River Landing .....	.....	.....	.....	High-water 1865 was equal to 1862, but just above Chin's crevasse it was 3.5* feet lower.
Carrolton .....	.....	+0.83	.....	
Algiers	+0.2	+0.7	.....	
Brashear City, Berwick Bay .....	.....	.....	.....	High-water 1865 was 1* foot below 1862, and Teche overflowed its banks in low places to Franklin.
Mouth of Bayou Tensas .....	.....	.....	.....	High-water 1865 was 1.8* feet above highest previous flood.

I transmit herewith a diagram showing the daily oscillations of the river at the place where the party was. It may be considered a mean curve for the vicinity between Helena and Providence.

The following are the checks furnished for the levels. The profiles are plotted without change, but on the maps the revised mean reading is given to the bench-marks.

Starting at Nibblet's, with bench-mark reading 98.20, the Prentiss bench-mark reads thus:

Route via Vermillion Lake	105.44
Route via Swan Lake.....	106.63
Route by river-bank.....	104.77

Mean 105.61

Starting at Grant's, with bench-mark reading 100.00, the bench-mark at Wilkinson's Landing reads:

Route direct from Wimbush's.....	104.42
Route via Old Port Royal.....	105.86

Mean 105.14

The accuracy of this mean determination is shown by the fact that the high-water marks on the profile from Robson's to Totten's check perfectly, the mean valve of the bench-mark at Wilkinson's Landing being adopted in placing the scale on the profile from Robson's to Delta.

By these levels the following slopes are deduced for the river-surface at high-water: Friar's Point to Grant's—distance, thirty-four miles; fall, 11.7 feet; slope per mile, 0.34 feet.

Prentiss to Nibblet's, distance 11.5 miles.....	{ Fall since cut-off, 3.5 feet. Slope per mile, 0.3 feet.
Prentiss to Nibblet's, distance 11.5 miles.....	{ Fall before cut-off, 3.2 feet. Slope per mile, 0.28.

It is to be remarked that the high-water mark at Delta is not so high by nearly half a foot as at Friar's Point, although five miles above it. This I attribute to the local influences on the mark selected of the large crevasses just above and below Delta, although possibly the levels may be at fault. On this account I have selected Friar's Point in preference to Delta to deduce the true fall in water-surface. The mean slope from Memphis to Gaines's Landing is 0.32 feet per mile. (See Delta report.) Also, the crevasses at Prentiss must have affected the high-water in 1865 sufficiently to obscure the true effect of the cut-off, which occurred on March 11, 1863.

A daily gauge-record is now kept at New Orleans by Mr. G. W. R. Bayley, city engineer, and at Cairo by the engineer of Cairo City Company.

The State of Mississippi has recently re-organized her levee system by creating a levee district of Issaquena, Washington, and Bolivar Counties, allowing Coahoma and Tunica to join if they so elect. A levee-tax annually of 10 cents an acre and 1 cent per pound on cotton is levied for three years.

The old Delta Survey Bench No. 1, on the curb-stone near Prentiss's house, Vicksburg, has been moved, and is consequently now worthless.

The low-water mark of 1863 at Saint Louis was 0.5 lower than that of 1860, the lowest heretofore recorded. It was 41.3 feet below high-water in 1844, and 33.7 feet below the Saint Louis directrix.

At 4 p. m. of March 13 there was a furious tempest, followed during the night by as heavy a rain-storm as I ever witnessed. My party was at Friar's Point, Mississippi. At 9 a. m. of March 13 the river stood 5.2 feet below high-water of 1855, having fallen 0.1 in the preceding twelve hours. At 9 a. m. of March 14 it was 5 feet below this flood-level, having fallen nearly an inch since daylight. No wind affected any of these readings. It is therefore evident that the rain, by its strictly local effect, raised the river at least 5 inches during this storm.

My attention was called to some singular springs in the bed of Bayou Hushpuckana. They are several in number, and some of them are located on the map. The largest of them is near the bridge. It flows freely up from several places over an extent of half an acre. The soil is covered by a yellow, slimy deposit, with a metallic-blue scum near the rills of water, which has a decided chalybeate taste. All these springs are in the bed of the bayou, and from 20 to 30 feet below high-water level of the Mississippi. Major Severson informs me that they flow all summer, even when the river is at low-water level, (45 feet below high-water,) and that the water is much colder than the water in the vicinity. Not understanding how these springs could exist in a purely alluvial region, I thought that some evidence bearing upon the age of the region might be derived from an analysis of the water and deposit. I accordingly procured samples of both, and submitted them to Dr. Charles T. Jackson, of Boston, whose reputation as a scientific chemist and geologist is well known. He gives me the following as the result of his analysis:

Water contains in solution: Bicarbonate of lime, sulphate of lime, carbonate of iron.

Deposit consists of: Crystallized sulphate of lime, carbonate of lime, sulphide of iron, slate mud.

He considers that the spring derives its character from decomposing iron pyrites, which most probably belongs to a tertiary formation.

From the facts that none of the tertiary river-bluffs are within many miles of the locality of these springs, which are near Sunflower Landing, opposite Island 66, in the Yazoo bottom-lands; that their level corresponds with the appearance of the blue clay, and that iron pyrites can hardly be considered an alluvial deposit of the Mississippi, I think that the conclusions as to the slight depth of the alluvium in this vicinity advanced in the Delta report receive strong confirmation from the existence of these chalybeate springs.

Brevet Captain Mackenzie reports that a cut-off has occurred at Terrapin Neck, which early in April was 300 yards wide. The newspapers, I suspect a little prematurely, reported it to have occurred on March 8, 1866. I have had every reason to be pleased with the manner in which Brevet Capt. A. Mackenzie, Corps of Engineers, and the party generally, have labored to accomplish the ends of the survey.

I am, general, very respectfully, your obedient servant,

HENRY L. ABBOT,

Major of Engineers, and Brevet Colonel. U. S. A.

Maj. Gen. A. A. HUMPHREYS,
U. S. Volunteers.

APPENDIX N.

ANNUAL REPORT OF MAJOR WM. E. MERRILL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1874.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, September 1, 1874.

GENERAL: I have the honor herewith to transmit annual reports on the works under my charge for the fiscal year ending June 30, 1874.

Lieut. F. A. Mahan, Corps of Engineers, has been my military assistant during the year, except from December 8, 1873, to May 14, 1874, inclusive, during which time he was on temporary duty at Savannah, Ga., under the orders of Lieut. Col. Q. A. Gillmore, Corps of Engineers.

Very respectfully, your obedient servant,

WM. E. MERRILL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

N 1.

IMPROVEMENT OF THE OHIO RIVER.

At the beginning of the fiscal year the following contracts were outstanding.

Number.	Miles from Pittsburgh.	Work.	Contractors.
1	3	Repair of Chartier's Creek dam.....	Charles Cable.
2	90	Repair of Wheeling dam.....	C. M. Cole.
3	168	Repair of dam at head of Marietta Island.....	C. M. Cole.
4	214	Repair of dam and dike at Buffington Island.....	C. M. Cole.
5	783	Construction of dike at Evansville, Ind.....	J. S. Routh.
6	907	Repair of dam at Cumberland Island.....	Miller & Bedard.
7	967	Removal of the Bacon Rock.....	Miller & Bedard.

Chartier's Creek dam, three miles below Pittsburgh.—This dam was completed in August, 1873, and the contract was closed. The total amount of stone expended under this contract was 32,480 cubic yards. It has answered its purpose satisfactorily. It closes the left channel at Brant's Island, throwing all the water in low and ordinary stages into the Glass-honse Channel.

Wheeling dam, ninety miles below Pittsburgh.—The repairs of this dam were finished in August, 1873. They required in all 3,508 cubic yards of stone and 425 cords of brush. It closes the right or Ohio channel at Wheeling Island, thus increasing the low-water volume in the other channel.

Marietta Island dam, one hundred and sixty-eight miles below Pittsburgh.—This dam is at the head of Marietta Island, and closes the right or Virginia Channel. The work of repairing this dam was completed in September, 1873. It required 8,304 cubic yards of stone and 177 cords of brush. It backed up the water so much more than I had expected that I thought it expedient to strengthen it by a brush and pile dam below, and thus divide the fall, which at certain stages was as great as $5\frac{1}{2}$ feet, and was more than I considered it prudent to attempt to sustain by a dam of loose stone. I therefore had an auxiliary dam built, whose upper line was placed 50 feet below the lower edge of the main dam, with its top surface 3 feet lower than that of the latter. This auxiliary dam was made as cheaply as possible of two rows of piles, 6 feet apart, with 30 feet between the rows, and the inclosed space was filled with brush, weighted down with stone. Some stone and brush were likewise used in protecting the banks. This auxiliary work required an expenditure of 316 piles, 5,941 cords of brush, and 4,553 cubic yards of stone. There has been no trouble in using the right channel since the left one was closed, except occasionally at the foot and opposite the mouth of the Muskingum. This river sometimes throws out a mass of sand and sediment that occasionally troubles coal-fleets. This difficulty has lately been removed by dredging.

Buffington dam and dike, two hundred and fourteen miles below Pittsburgh.—These works were finished in September, 1873. The total amount of stone expended on both was 26,078 cubic yards.

Eransville dike, seven hundred and eighty-three miles below Pittsburgh.—At the close of operations in 1873, this dike had been finished for a length from shore of 1,025 feet. I directed Mr. Charles B. Bateman, assistant engineer, the inspector of this and Henderson dikes, to examine the dike occasionally during the winter, and especially to report any effect that might be produced on the sand-bar at the upper end of the city, for the removal of which the dike was designed. He reported on the 31st of December that the deposit on the wharf from the recent rise is much less in quantity than usual; also that from the line of the highest water said deposit is clayey mud down to about the 20 foot line, from which line down it consists of sand and gravel in patches evidently washed from the bar. * * * The current during the rise and since the river has commenced falling, has been decidedly on the Indiana shore, the drift giving considerable trouble to steamers and wharf-boats at the landing.

On the 30th of March he wrote :

I observe that during the several rises of the past few months there has been no deposit on the wharf below 23.50 feet on the gauge at that stage, and below a strong current sweeps the Indiana shore from the water-works down—the effect, it is presumed, of the dike.

On the 23d of May he writes :

Soundings were taken over the bar from Mulberry street to Main, when the river was at 12 feet by the gauge, and were as follows :

	Feet.
On highest part of the bar, opposite Mulberry street	7.50
Opposite Cherry street.....	8.60
Opposite Chestnut street.....	9.00
Opposite Walnut street.....	10.50
Opposite Locust street.....	12.00

Below Locust street, no bottom at 12 feet, showing that at least four feet has been taken off the bar during the past winter. The current on this side is stronger than before, and there is evidently a channel cut along the scour made along the bar during the winter of 1872-'3.

On the 1st of June he writes :

On the bar in front of the city I made soundings, and found one little ridge opposite the water-works, near the shore, which is now four feet above low water. No other part of the bar will be more than 2.50 above low water when dry. Opposite the foot of Main street, where the bar used to be, there will be six feet at low water.

The dike itself is firm and solid, and a large sand-bar has formed below it. The dike will be extended 300 feet farther during the present season. I have purposely kept this work back, in order to give the river time to accommodate itself to the new course marked out for it. A rapid construction of the dike would have caused so great a scour at its outer end as to materially increase its cost. At present the pocket behind the bar has been filled by material washed into it from the bar, and more or less of the same is scattered along the city front, making landings difficult in low water. This temporary annoyance could not have been prevented. The bar is still so high that in extreme low water it cuts off the river current. When the bar is entirely washed away these troublesome deposits will depart with it. I consider this dike a marked success in its effectiveness, its strength, and its cheapness. All future dikes in the Lower Ohio will be built in a similar manner.

Cumberland dam, nine hundred and seven miles below Pittsburgh.—The repairs on this dam were completed in December, 1873, under contract with Messrs. Miller and Bedard.

The total amount of stone used was 20,187 cubic yards. Owing to the long duration of high-water last autumn, at a time when the river is usually at its lowest, it was impossible to finish this work as completely as was desired, as during the last six weeks the dam was continuously under water. I made as close a personal inspection as was practicable, and, feeling satisfied that nothing more could be done to advantage, closed the contract. During high-water of the winter and spring the dam was subjected to a severe test. All of the new work except a small section about 100 feet in length stood very well, but to my surprise the river leveled down a large part of the old work which had been standing for over thirty years, and was assumed to be safe and strong. During the present season I called for proposals for bringing this part of the dam up to grade, and let the new contract to Mr. Bedard, the active member of the old firm of contractors. He bid at his old price, which was considerably lower than the price offered by any other bidder. Six thousand yards more will be placed in the dam, and there is reason to believe that this amount will make it safe and substantial. There will always be a strong pressure against it, as the high-water current is over the dam, and therefore deposits will annually form in the chute, which must be removed by the current as the water falls and is forced by the dam into the chute. Thus far there has been no serious trouble with the new channel at the head of Cumberland Island, but

that at the foot of the island is changeable, and will probably require some construction to fix it.

Bacon Rock, nine hundred and sixty-seven miles below Pittsburgh.—This rock was formerly on the Missouri shore of the Mississippi River, but owing to the gradual change of the channel of the Mississippi it is now in the Ohio River, though a slight wash of the sand-bar between the two rivers would throw it into the Mississippi. It is a very serious obstruction in low-water. The contractors, Miller and Bedard, did nothing for the removal of this rock, and their contract was declared forfeited. One of their sureties, Mr. M. A. Bryson, then claimed the right to complete the contract, and his right was acknowledged. During low-water last season he made some preparations, and waited for the water to fall before commencing work. Contrary to custom the river rose, and remained up, consequently nothing was done. During the present season, at my suggestion, he employed Capt. R. W. Dugan, of the Cincinnati Wrecking Company, to do the work for him. At the close of the year Captain Dugan had exploded, by surface-blasting, a large number of charges of dynamite on the rock, and had entirely broken up its shell. He found the interior of the rock (which is a pudding-stone) to be mainly loose gravel. This will be removed by a dredge, and before this report reaches Congress the Bacon Rock will probably be a thing of the past.

NEW CONTRACTS.

The following new contracts were made during the fiscal year just past:

Number. Miles from Pittsburgh.	Work.	Contractor.
1 2	Dam across Duck Chute	C. M. Cole.
2 760	Repair of old dike at French Island	C. M. Cole.
3 797	Repair of old dike at Henderson Island	J. S. Routh.
4	Construction of dredges and dump-scows	S. B. Alger.
5	Construction of iron snag-boat hull	Swift's Iron and Steel Works.

Duck Chute, two miles below Pittsburgh.—Duck Chute is a small channel across the bar at the head of Brunot's Island, and near the high land of the island. It is usually dry at extreme low-water. It was necessary to close it, as the current through this opening drew coal-fleets out of the channel leading into Glasshouse. The dam was finished in September, 1873, having consumed 1,995 cubic yards of stone. It entirely closed the channel across which it was built, but the pressure of water in that direction was so great as to cut out the gravel at each end of the dam, and as much water now escapes as before its construction. If the radical improvement of the Ohio be inaugurated it will probably be unnecessary to extend this dam; if the contrary be the case, its extension will be very necessary.

French Island Dike, seven hundred and sixty miles below Pittsburgh.—Since the close of the fiscal year this dike has been completed, as also some slight repairs to the dike, extending down from near the foot of the island. The work has given great satisfaction to the Louisville and Henderson packets, as French Island was the shoalest place on their route. Three and a half feet is as much as I think can be depended on in extreme low-water, though the contractor thinks he can guarantee 4 feet. A greater depth might be secured by a greater contraction, but

that is inadmissible on account of the coal-interest. The following quantities of material were used: 2,815 cubic yards of stone, 5,409 cords of brush, and 705 piles. The total length of the new dike is 2,000 feet.

Henderson Island Dike, seven hundred and ninety-seven miles below Pittsburgh.—At the close of 1873 this dike had been extended into the river 1,000 feet. Its effect was excellent from the first, a good channel having been maintained throughout the low-water season. Unfortunately this good effect was not lasting. During low-water of June, 1874, the slight obstruction to the flow of the river occasioned by the dike was enough to cause the channel behind the island to cut out, and in extreme low-water steamboats had to take that route. This channel was very narrow and intricate, and was full of snags and water-soaked logs, making an exceedingly bad place for steamboats, and one quite impracticable by night. I made a careful personal examination, finding $3\frac{1}{2}$ feet at the head of the chute, and less than 3 feet in the old channel, the river being a foot or two above dead low. No steamboat could get through the chute without hitting at least one log. I concluded that the proper remedy was to close the chute entirely by a pile and brush dam, thus forcing all the water through the channel marked out for it. This work was approved by you, and is now under way. At present the dike is finished for a distance from shore of 1,050 feet, and piles have been driven for an additional distance of 250 feet. It will be extended to a total length of 1,500 feet.

I have always been apprehensive of the possible need of a dam behind Henderson Island, but I was unwilling to spend the money needed to build it until its necessity was demonstrated, and the fact that in former years no such dam had been built strengthened me in my conclusion that it might prove unnecessary now.

New dredge and dump-scows.—The new dredge Oswego and two dump-scows have been built by Mr. S. B. Alger, under his contract of July 11, 1873. The hull of the dredge is 75 feet long and 30 feet wide, with 5 feet 9 inches depth of hold. She draws 2 feet 8 inches of water when loaded with 600 bushels of coal. Her cylinders are 10 inches in diameter, with 14-inch stroke, and she is provided with one of King's marine-boilers, having eighty 3-inch return-flues. A steam hoisting-apparatus is provided for the forward spuds, and a steam-capstan for maneuvering. The clutch used is Alger's patent friction-clutch. It is somewhat liable to breakage, but when in order works rapidly and well. By making it of steel, and keeping a spare clutch on hand, there need be no serious loss in case of accident. The scows are side-dumpers, with bins capable of holding 71 cubic yards. They are 65 feet in length and 20 feet in width, and have 4 feet depth of hold. They are built without crown or sheer, and draw when empty 15 inches. They can carry 50 cubic yards of gravel on 3 feet 6 inches of water. The contract-price of dredge and scows was \$18,500. An additional sum of \$2,000 was spent on outfit, making the total cost of dredge and two scows about \$20,500.

Iron hull snag-boat.—The contract for building the hull of the iron snag-boat for the Ohio was taken by the Swift Iron and Steel Works, at \$84,350. During the winter but little work was done, on account of the financial depression and of strikes at the works. At present everything is progressing rapidly, and the hull is about one-third finished. Its construction will supply a long-felt need.

Traveling sands in the Ohio below the falls.—The greatest obstacle to the successful improvement of the Lower Ohio comes from the enormous masses of sand and gravel that travel down stream during every rise.

Behind the dikes at French and Henderson islands, and at Evansville, sand-bars have formed as high as the dikes, and in places where before, or during their construction, there was deep water. At the Cumberland Island end of the Cumberland dam, where last season there was about 10 feet of water, there was this season 10 feet of sand, showing a deposit of 20 feet in one season. The sand behind the dikes mentioned above is mixed with gravel, and as it is impossible for gravel to be carried in suspension, it must have rolled along the bottom. The up-stream sides of the dikes are vertical, or nearly so, and I can see but two ways for the gravel to get over the dike. It might have reached the upper line of the dike and there got attached to ice which carried it over when the river rose, and then dropped it below the dike. This action has undoubtedly taken place at Louisville, at the revetted slope on the up-stream side of the dam at the head of the falls. The other supposition is that in high water the bottom of the river was raised by deposit to the level of the dike, and that before the dike became visible the deposit on its up-stream side was washed away. This I think the more probable explanation, especially in view of the fact that during the ice-period of last winter all of the dikes were submerged many feet. There is abundant additional experience to show that during high-water the bottom of the river is habitually raised by deposit, and that the low-water channel is subsequently cut out of it as the river falls. This condition makes the radical improvement of this part of the Ohio a matter of serious difficulty. A further discussion is reserved for the report on the radical improvement of the Ohio, which has been ordered for the Senate Committee on Transportation.

DREDGING.

The work of dredging has been vigorously prosecuted during the year, under the direction of Mr. E. J. Carpenter, assistant engineer. On the 1st of July, 1873, the "Ohio" was at Captina. The cut at this place was finished by the removal of 260 more yards, and the dredge was moved to Baffington Island. The "Ohio" continued work on the bar at this place, which is one of the worst on the river, until compelled by cold weather to lie up. She dredged 8,983 cubic yards in July, 10,285 in August, 11,907 in September, 6,662 in October, and 2,760 in November, making a total of 40,596 cubic yards. During the last month the new dredge Oswego joined her, but neither dredge could do much, on account of high-water. The work of the "Oswego" amounted to but little, as all of her machinery was new and required to be worked into smooth running. The little dredging done by her has been credited to the "Ohio."

The dredges were laid up at Marietta in the mouth of the Muskingum until the 1st of May. They were then sent to Pittsburgh to remove the bar at the foot of Brunot's Island, which gave great trouble to coal-fleets. Sixteen thousand two hundred cubic yards were removed in May and 21,839 in June, making a total of 38,038 cubic yards removed from the bar. No further difficulty is anticipated at this place. The dredges are still at work, but their subsequent operations belong to the present fiscal year.

REMOVING WRECKS AND OBSTRUCTIONS.

The winter of 1872-'73 was unusually severe, and when the ice broke up it destroyed many river-craft, and left numberless wrecks in the channel which could not be discovered until low-water of summer.

Capt. R. W. Dugan, with the boat of the same name, blew up and removed the wreck of a section of dry-dock that had lodged in the channel at Rising Sun, and the wreck of the steamboat McCullough near Madison. Captain Hobson, with a crane-boat, removed several logs and minor wrecks in the immediate vicinity of Cincinnati. There were several wrecked coal-barges in the channel at Vevay. I tried to get a dredge from the Louisville Canal for this work, but, being unsuccessful, I made application to the Kanawha board, and was permitted to hire a dredge from them. This dredge removed the barges at Vevay, but a sudden rise in the river compelled her to stop work and return to the Kanawha. In August one large log was removed by a crane-boat from the channel at Cullum's Ripple, and another lying opposite Covington.

The navigation of the Ohio being greatly hindered in low-water at Mustapha Island, Guyandotte Shallows, Poag's, Jenalt's, and other places, I had a large grapple built for the express purpose of removing bowlders. This grapple is 11 feet in height, has a grasp of a little more than 5 feet, has four fingers on each side, weighs 2,700 pounds, and cost \$1,174. The following obstructions were removed by the use of this grapple: the rocks at the foot of Mustapha Island, where the channel is now in good condition; several rocks in the channel-span of the Parkersburg bridge, carelessly thrown there by the bridge-builders, and two snags between Parkersburg and Marietta. This grapple has been used to great advantage on the Great Kanawha. For details, reference is made to the annual report of operations on that river.

A snag was removed by hired labor from the foot of Ranty's Shallows, and the Government snag-boat S. H. Long was borrowed from Major Suter, engineers, and was employed four days in cleaving out the chute at the head of Cumberland Island.

During October, four troublesome snags were removed from Quick's Run Bar by a hired crane-boat. A section of the dry-dock was blown up at the foot of Ludlow street, Cincinnati, and the greater portion of the wreck of a stone-boat was removed from Rising Sun bar. A sudden rise in the river prevented its entire removal.

A wrecking-party provided with diver, armor, battery, and torpedes was equipped and put to work at the wreck of the Missouri, a very large and strongly-built steamboat, lying just above the Evansville dike. About half of this boat was removed by the close of the season.

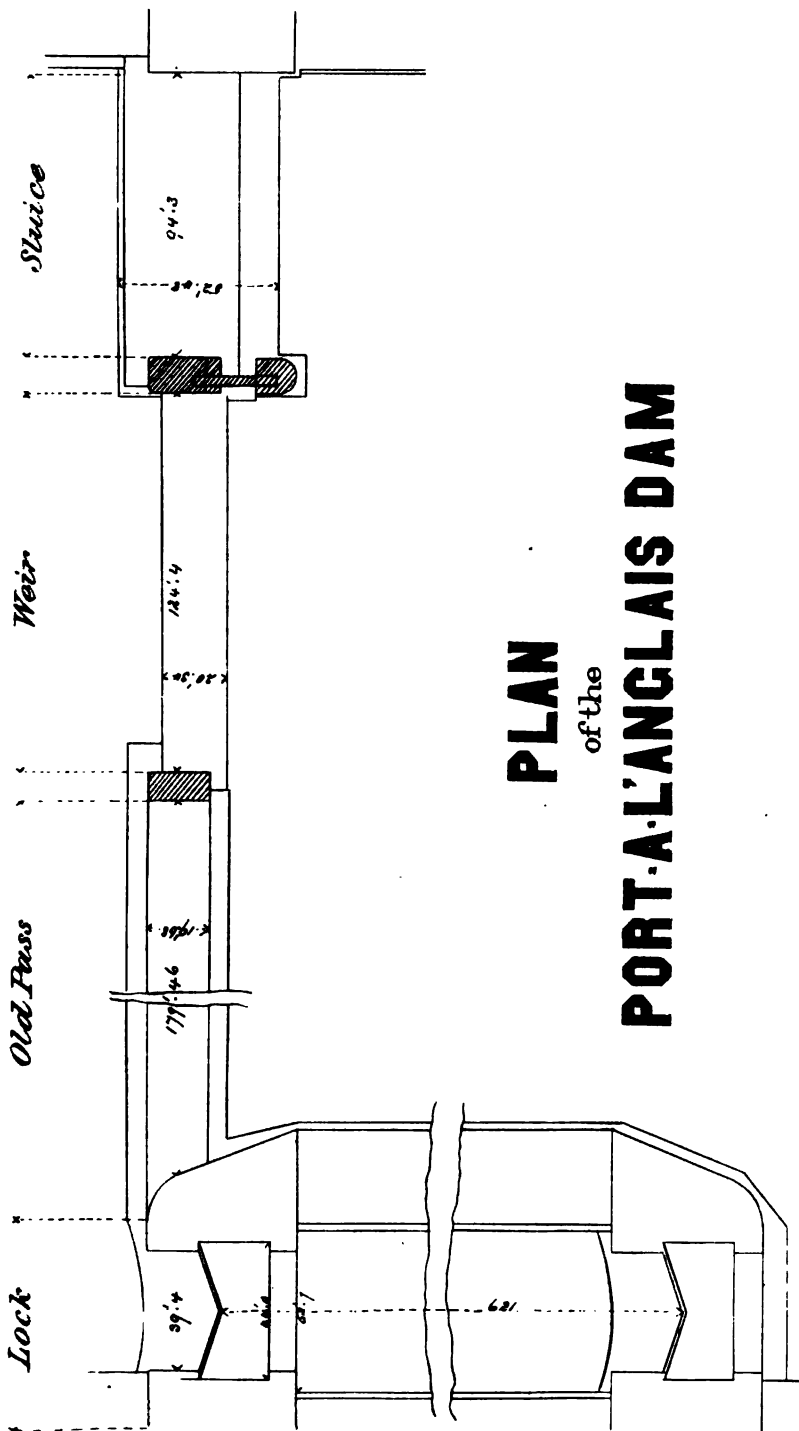
In May, one log was removed from the mouth of the Muskingum, and three others from the head of Blennerhassett's Island.

OFFICE-WORK.

The office-work during the year has comprised the preparation of a continuous map of the river, on the scale of 2 inches to the mile, of detailed drawings for the snag-boat, of hydrographs of the Ohio River gauge-records, of drawings to accompany the report of the Board of Engineers on movable dams and hydraulic gates, of drawings and tracings of special surveys, and of miscellaneous work of various kinds.

ESTIMATE FOR 1875-76.

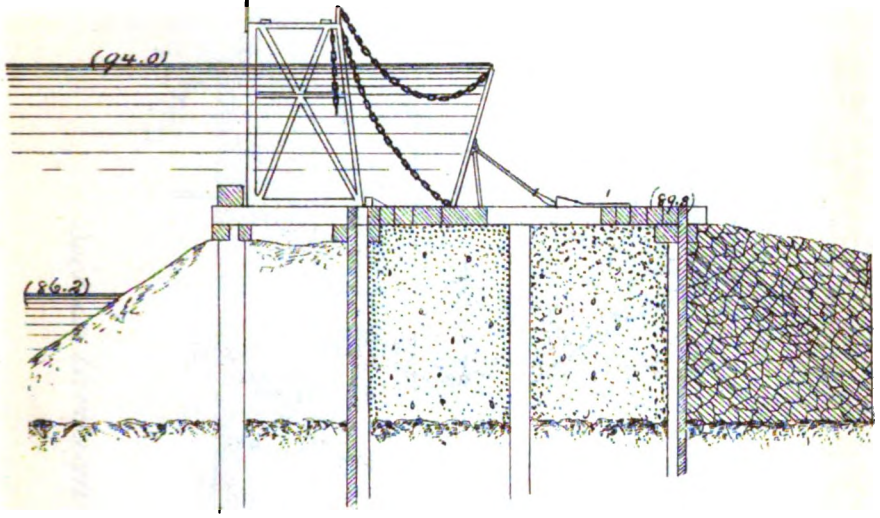
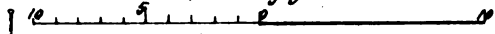
The first question to be settled is the general method of improvement. After long study, I have come to the conclusion that the best method of improving the Ohio, at least in the upper part of its course, is to follow the plans that have been so successful on the Seine, Yonne, Marne,



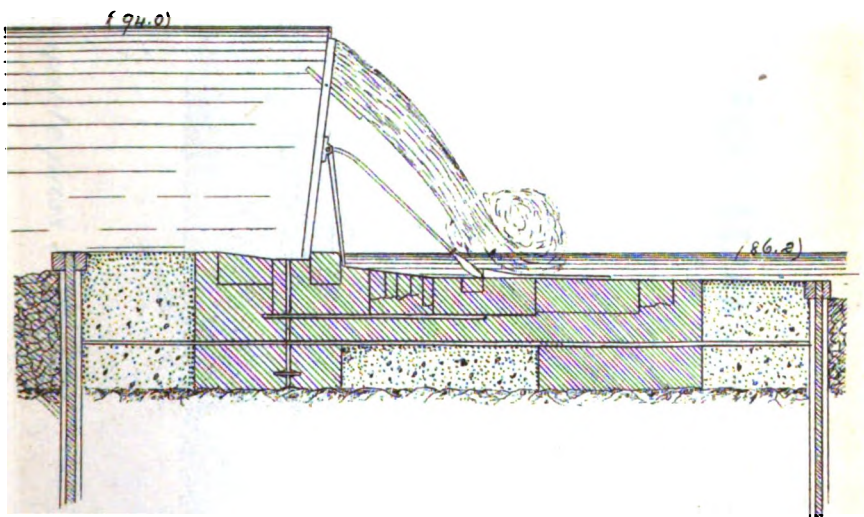
PLAN of the **PORT-A-L'ANGLAIS DAM**

PORT-A-L'ANGLAIS DAM

Scale of feet.



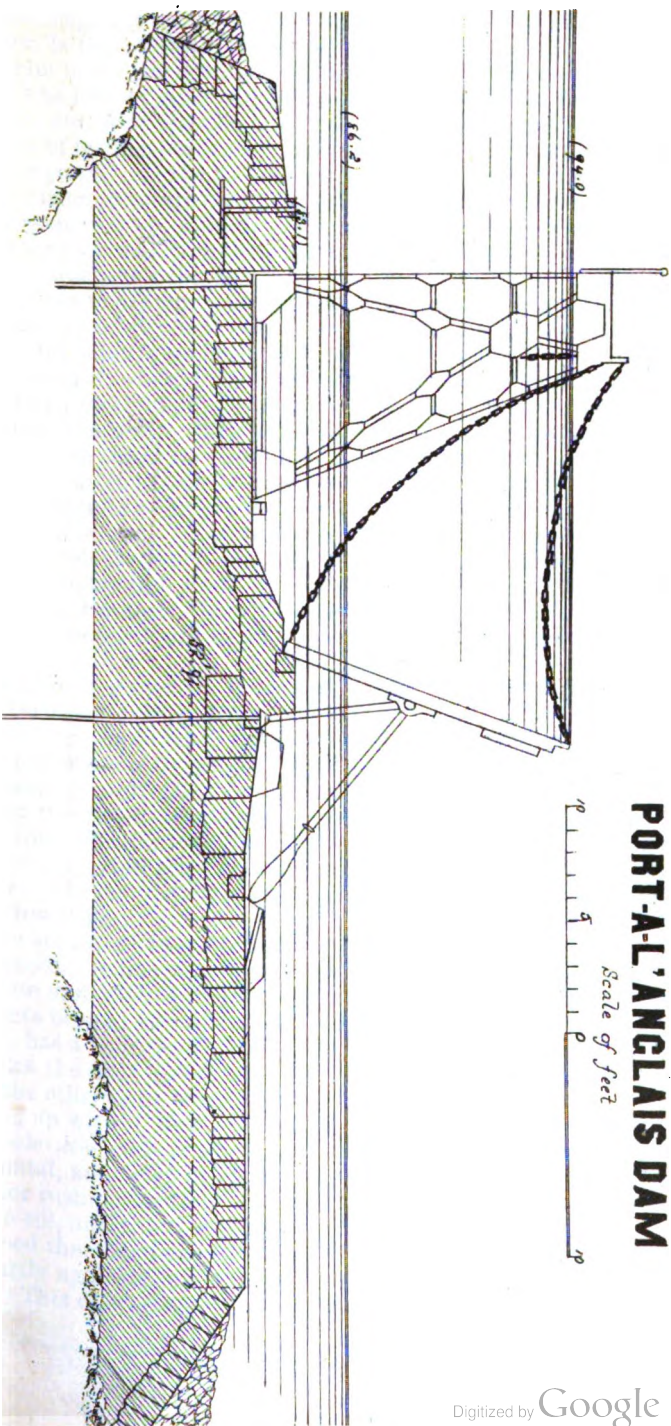
Section through weir



Section through old navigable pass

PORT-A-L'ANGLAIS DAM

Scale of feet
0 5 10



Section through new navigable pass or sluice

Meuse, and other French rivers. The details of all the methods in use in France are given in full in the report of the Board of Engineers on movable dams and hydraulic gates, which is printed as Ex. Doc. No. 127, H. of R., 43d Cong., 1st sess.* The system that meets with most favor in France is that known from its inventor as the Chanoine. A drawing of the more important features of this system accompanies this report. The Brunot gate will probably be a useful auxiliary to this or any other system that may be adopted, and I had expected to have an opportunity of testing its practicability on a working scale before the meeting of Congress. As it has been decided that money appropriated for the Ohio cannot be expended on a dam in the Monongahela, this trial has necessarily been abandoned. While I regret this, I do not consider that its lack will have any influence on the method of movable dam that may be selected for use.

There is nothing to prevent the subsequent trial and adoption of the Brunot gate on one of the movable dams should it seem desirable. It is merely a useful adjunct at best, and not an indispensable necessity.

A Chanoine wicket, when in position, is a solid frame of timber about 3½ feet wide and 13 feet high, sloping down stream and supported behind by a heavy iron prop. The horse is hinged to the wicket and to the floor. The prop turns on the upper axle of the horse, as does also the wicket. The latter is not fastened to the floor except by the horse, and can swing around the upper axle of the latter when not held down by the pressure of water. A series of such frames or panels makes the dam. The intervals between the frames are about 2 inches, and if it is necessary to make the dam tight these intervals can be covered. Usually the waste through them will be less than the discharge of the river, and therefore the level of the pool will not fall below the tops of the wickets.

The dam is thrown down by means of a long iron bar laid on top of the masonry-base, extending from one shore to the other, and armed with projections or shoulders. By moving this rod a few feet, which is done from the abutment by proper gearing, the feet of the props are tripped successively, and the wickets fall into a shallow recess where they are below the reach of passing boats. The river is then in its natural condition, offering no obstacle to boats nor to the passage of floods. In the navigable pass nothing projects higher than 2 feet below low-water line. On the weir the height of masonry is usually about 20 inches above low water.

The wickets are raised in succession by the use of a boat which works across the stream. It has a sheave in its bow, and a geared drum near the stern. The first wicket is raised by the boat being so placed that its bow projects beyond the abutment half the width of a wicket. The hoisting rope has a boat-hook fastened to its outer end. The man at the bow hooks the boat-hook over a handle at the lower end of the wicket, and the other man then winds up the rope. The wicket is thus raised, pulling up with it the horse and the prop. When the horse is at its proper elevation the prop drops into position. The wicket is still nearly horizontal, and if it is let go it will retain an inclined position with the water rushing under it. A slight push on its lower end brings it against the sill, and the water pressure holds it in place. After one wicket is raised the boat is pushed out the width of a wicket, supporting itself partly against the abutment and partly against the wicket first raised. This operation is continued until all the wickets are in place.

* See Appendix N 3.

At many dams there is a temporary bridge above the wickets from which they are raised. This is probably the better method, but in a wide river it would probably cause some delay in getting the wickets up, unless a considerable force of laborers were kept on hand to expedite operations. Two or three men are all that are employed in France to manage a lock and movable dam.

Assuming then a method of improvement by movable dams on the Chanoine plan, we require the following constructions:

1. A movable dam of Chanoine wickets divided into navigable pass and weir.

2. A lock large enough to pass an ordinary coal-fleet through in one lockage.

The dams should have a vertical height of 12 feet, that being as far as present experience goes, about the greatest practicable height of a movable dam. The lift from one pool to the next will be 6 feet, and there will be a minimum depth of 6 feet below each dam, thus securing a 6-foot navigation at all times.

I have already chosen the approximate position for a sufficient number of dams to make a 6-foot navigation at all seasons between Pittsburgh and Wheeling. I do not think it advisable to make an estimate at present for extending this work below Wheeling. The sites and length of dams are as follows:

No.	Place.	Miles from Pittsburgh.	Length.
			<i>Feet.</i>
1	Just below Horsetail Ripple.....	5½	900 + 600
2	Between Duff's and Merriman.....	8½	1,000
3	Just below the trap.....	12½	1,500
4	Just below Deadman's Island.....	15½	1,300
5	At Crow Island.....	21	1,350 + 400
6	Below Montgomery's Island.....	32½	1,600
7	One mile below Georgetown Island.....	38½	1,300
8	Just below Baker's Island.....	49½	1,850
9	One and a half miles below Black's Island.....	55	1,700
10	One mile above Steubenville Bridge.....	65	1,000
11	At Cox's Bar.....	72	1,250
12	At head of Pike Island.....	83	1,700
13	At Wheeling.....	90	1,000 + 800
	Sum.....		19,150
	Average length.....		1,473

Where two lengths are given in the above list, the dam rests on an island, and there are two channels to be closed.

The width of navigable pass is an undetermined quantity. Coal-fleets are generally four barges or 100 feet in width, but at times they have a width of five barges, (120 feet,) or even of six barges, (144 feet.) As they will have the smooth wall of the lock to guide them into the pass, I think it will be quite safe to limit its width to 250 feet. The rest would be weir and Brunot chute, should the latter prove a success, or weir only if the contrary.

Experience in France shows that the locks should be large enough to pass a coal-fleet, either ascending or descending, at one lockage. An average fleet has ten barges, (130 by 24 feet,) one fuel-flat, (100 by 22 feet,) and one steamboat, (230 by 48 feet.) The barges could pass two abreast if the locks were 50 feet wide, three abreast if they were 75 feet, four abreast if they were 100 feet wide. The first size is, however, too small for packet-steamboats which require from 60 to 80 feet, and the last-named size is too wide to be closed by the ordinary lock-gate. The width of the lock must therefore be 75 feet.

To hold such a coal-fleet as I have described above, the available length of lock must be 620 feet, and this should be increased to 630 to give play for the gates, and to avoid a tight fit.

The lock should therefore be built with a length between miter-sills of 630 feet, a width of 75 feet, and an ordinary lift of 6 feet, but with strength enough to sustain a pressure of 10 feet, which would happen should the lower pool be emptied in low-water.

This length may seem excessive, but the advantage of passing a fleet at one lockage is very great, and the increase of cost is not in proportion to the length of lock. The most expensive parts of a lock are the gates and the masonry around them, and these cost the same in all locks of the same width and lift, regardless of their length. The difference between a short and a long lock of the same width and lift is only the cost of the extra length of chamber wall, and this is the cheapest masonry about the lock. The fleets on the Seine are somewhat smaller than those on the Ohio, though their larger barges have almost exactly the same dimensions as Ohio coal-barges. (See Ex. Doc. No. 127, H. of R., 43d Cong., 1st sess., page 51.) To pass one of these fleets at a single lockage, the lock-chambers on the Upper Seine have a width of 40 feet, and an available length of from 591 to 615 feet.

In order to avoid delay and waste of water when a single steamboat wishes to pass through, the locks should have extra gates at the middle, so that the whole length of lock need not be used unless occasion called for it. This will add somewhat to the expense, but I believe that the advantages of diminishing the amount of water needed for lockage during very low stages, and of expediting the passage of packet-boats, will be worth obtaining.

The cost of such a lock as I have described, would be, in round numbers, \$200,000. The cost of 13 such locks will therefore be about \$2,600,000.

These figures will be somewhat modified when a detailed estimate can be prepared. A special party is now at work definitely locating the proposed dams that I have approximately located above, and making borings to determine the character of foundation at each site. This information will be embodied in the report ordered for the Senate Committee on Transportation, and will somewhat modify the approximate estimate herewith presented.

The cost of the movable dams will be:

\$344 per running foot for the pass.

\$227 per running foot for the weir.

These estimates for the dams have been carefully prepared under my direction by Lieutenant Mahan, by using the itemized bills of materials prepared from actual construction in France, and are believed to be quite accurate. No account has been taken of the Brunot chute, which, if successful, will replace a part of the weir. It would, however, increase the cost of a dam.

A movable dam of the average length of 1,473 feet will then cost as follows:

250 feet of pass, at \$344 per foot.....	\$86,000
1,273 feet of weir, at \$227 per foot.....	284,971

Total for one movable dam	374,971
Thirteen movable dams without locks will therefore cost.....	4,874,623
The cost of a single lock with movable dam will be.....	574,971
And the whole cost of this improvement from Pittsburgh to Wheeling.....	7,474,623

In beginning this work we should first build the locks, as during the construction of the dams they will answer as waste-weirs, and will also

keep open a passage for navigation. I think that at as early a date as possible this work should be simultaneously begun at all points between Pittsburgh and Wheeling, because it will take all of two seasons to build these locks, and their construction must precede that of the dams. There is no doubt whatever of the absolute necessity of using locks in any rational plan for improving the Upper Ohio so as to secure a 6-foot navigation. Whatever changes may be made in the details of the dams, the locks must be the same.

For this part of the improvement of the Ohio, I therefore now ask for..... \$2, 000, 000
Engineering and contingencies of lock-construction, 5 per cent..... 130, 000

Besides this special sum, I request the following :

To complete snag-boat.....	\$35, 000
To keep dredges at work 9 months, at \$3,000.....	27, 000
For six months' service of snag-boat, at \$3,000.....	18, 000
For improving Lower Ohio by dikes.....	170, 000
Office expenses.....	20, 000
Total.....	3, 000, 000

I have not thought it necessary to attempt detailed estimates on the dikes for the Ohio below the Falls, as this work is so dependent on unforeseen contingencies that such estimates are of little value. The bars that are in most need of improvement are Portland, Flint Island, Puppy Creek, Scuffletown, Three-Mile Island, Shawneetown, Treadwater, foot of Cumberland Island, and the Grand Chain.

Financial statement.

Balance in Treasury of United States July 1, 1873	\$230, 000 00
Amount in hands of officer and subject to his check, (including \$4,620.30 percentage due on contracts not yet completed)	26, 675 96
Amount appropriated by act approved June 23, 1874	150, 000 00
Amount expended during the fiscal year ending June 30, 1874	207, 246 47
Amount available July 1, 1874, (\$199,349.49—\$4,525.65)	194, 823 84
Amount required for the fiscal year ending June 30, 1876	3, 000, 000 00

N 2.

IMPROVEMENT OF THE OHIO RIVER BELOW THE FALLS.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, November 30, 1873.

GENERAL: In reply to your letters of September 1 and October 1, I would submit the following in regard to the improvement of the Ohio below the falls so as to secure a depth of 5 feet at low water. I regret that I have been absent on duty so much lately, and have been so busy on board-reports, that I have been unable to take up the subject earlier; but as I gave my views at length in my testimony before the Senate Committee on Transportation, for whose information (as I was informed) these questions were asked, I trust that the delay has not been injurious.

The first question in your letter of September 1, reads as follows :

Please inform this Office whether you are prepared to submit a project for improving the Lower Ohio River, from Louisville to Cairo, so as to afford a depth of not less than 5 feet at the lowest stage of water known. If not, please state what additional information you require to enable you to prepare such a plan.

In reply I would state that the only plan which I am at present prepared to recommend is the one now in use throughout the whole river,

and that is the concentration of the currents by dikes or wing-dams, and the closing of all but one channel where there are two or more. Whether this method will secure five feet during dead low water I cannot now tell, but I am rather of opinion that it will not. It is possible that we might secure four feet, but experience alone will answer this question. I should state that no work was done on the Lower Ohio by Mr. Roberts, and that I have only commenced the work this season, and consequently have too little experience in this matter to give a positive reply. The dikes at French and Henderson Islands are both under way, but it is not likely that either will be finished this season. The latter was commenced first, and its effect was so quickly felt that there was no trouble at this bar during this summer's low water. But the mere fact of boats being able to cross this bar does not show the maximum that could have been brought over, as during the low-water season there was only 20 inches on French Island bar, (the work at that time had not begun there,) and from two to three feet on some others, and therefore all boats were running very light. Last year I commenced work at Cumberland Dam and at Evansville dike, but the object in view at each of these places was the changing of old channels, and not their deepening, and, besides, both of these works are unfinished.

One great difficulty in improving this part of the river is that the coal-fleets that start from Louisville for southern markets are much larger than those that come from Pittsburgh to Louisville, and this fact, together with the lack of definiteness in land-marks in the river below the Falls, makes it dangerous to reduce the channel-width below 600 feet, and of course the same depth cannot be expected in a wide as in a narrow channel.

There is another point on which reasoning is of little avail, and experience alone is to be trusted. That is, whether or not the sands that are swept through narrow artificial channels will not form below, and the practical result be simply a change of position of the bar, without increase of depth. If the work formerly done on the Ohio had been kept in good condition, and carefully observed and reported upon, we should now be able to settle this matter; but our records are unfortunately defective, and the old works have themselves been so degraded that they now exercise no perceptible influence on the bars. I have in this office all the records about the Lower Ohio that I could secure in the Department or elsewhere, and I herewith present, in chronological order, a summary of all the opinions on the effect of dams and dikes in the Lower Ohio which I could gather from the records.

The earliest report on file in this Office, which records the results of work on the Lower Ohio, is by Colonel Long, in reference to the dike at Henderson Island. His report is in the shape of marginal notes on the drawings which he forwarded to the Department. On his "Sketch No. V," a copy of which I send herewith, there is the following note. The remarks in brackets and the italicizing are mine:

From the diagram now before us it will be perceived that the bed of the river has undergone a material change since the commencement of our operations.

A portion of the sand accumulated above the dam during the freshet before mentioned [winter of 1824-'25] contributed to form the circular bar at the lower extremity of the dam, across the outward margin of which the depth of water is *only three feet* as represented in the sketch. A large quantity of sand previously situated in the bed of the river above the dam, was now distributed over the space between the dam and the dry-bar below, occasioning the shoal presented in that part of the river. The elevation of the bar above the dam, with the exception of the channel contiguous thereto, remained about the same as it was at the commencement of the work this year, although its position approximated considerably nearer to the island.

The general depth of water in this part of the river, at the time alluded to, was from $2\frac{1}{2}$ to 3 feet, but owing to subsidence of 18 inches, which took place during the progress of the work, its depth was now only about *one-half that above mentioned*. The position and depths of the channel, occasioned by the dam, are indicated by the drawing, in which are inscribed a series of soundings, corresponding to the depth of water actually found in the channel at this very low stage of the river. At the lower extremity of the channel the depth is *only 3 feet* for a distance of 12 or 15 yards; but the sand is here exceedingly loose and yielding, the current setting strongly across it, and daily rendering the channel deeper and broader. It is not expected that the channel occasioned by the dam will continue to occupy the position it now has longer than the present season, for the following reasons: The next freshet will probably bring down a large body of sand from above; and deposit it immediately above and below the dam in such a manner as to form a bar rising to the top of the dam throughout its whole length; such being the event, the most elevated part of the bar will be that portion of it situated contiguous to the dam, so that when the river subsides, the water, instead of being drawn off through a channel adjacent to the dam, as is now the case, will pass over a less elevated part of the bar at a considerable distance above it. Should the result prove as here stated, there can be little doubt either of the efficiency or permanency of the work, for it will then be protected from the undermining influence of the current, and secured from the shocks of floating ice and drift of every description to which it would otherwise be exposed.

I would particularly call attention to the following points on the sketch: The limited depth of water across the bar, the narrowness of the channel indicated, and the shoal formed below the dike.

Captain R. Delafield, Engineers, in his report, dated January 16, 1833, (Doc. No. 66,) states as follows about the work on the Lower Ohio:

The last class of works [deepening the water on the bars] has now been so far tested as to render no longer doubtful the success of removing the bars from their present position, and to this period entirely accomplishing the object in view of giving a permanent and unchangeable $3\frac{1}{2}$ and 4 foot channel-way.

With a judicious location of the dams, I am more fully confirmed in the belief that permanency may be secured to all such works, and that removing the bar from one point need not form another immediately below. This is the only doubt as to the entire success of the works of this class.

The results thus far have been satisfactory. Last year two of the most difficult and shoalest bars were dammed, as shown by figures 1 and 2 accompanying this report.

On the Scuffletown Bar (Fig. 2) there was formerly but 18 to 20 inches water at the low stage of the river. Since the dams have been constructed there is four feet, and no injurious formation below it, all the sands having apparently been deposited under the lee and eddy made by the dam, and the channel confined within permanent banks.

A reference to Fig. 2, No. 8, of my report of 1831, will exhibit the position of the shoals at that time, and the present sketch (Fig. 2) will give an idea of the change effected by constructing the dams.

Fig. 1 is a sketch of another system of dams constructed last year, that have been productive of satisfactory results at the Sister Islands. In this case, as the previous ones, the sands washed from the bars have been deposited under the lee of the dams. Fig. 4, No. 12, of the report of 1831, exhibits what was then supposed to be the position of the shoals at that time, and the sketch accompanying this report (Fig. 1) the present position of the shoals. If these two figures are correct, a very great change has been made in the whole bed of the river, proving the facility with which the channel may be deflected in any direction, and the necessity of having surveys for each and every one of these bars, to judge properly of the effect produced.

I append to this report copies of Captain Delafield's maps of the bars at French Island, Scuffletown, and the Sisters, the work being then under way at the first-named place, but finished at the other two. He shows a depth at French Island of $2\frac{1}{2}$ feet, at Scuffletown of 4 feet, and at The Sisters of $3\frac{1}{2}$ feet.

There are on file in this office sketches of the dams at French Island, Scuffletown, Three Mile, and The Sisters, made by Lient. A. H. Bowman, Engineers, in 1835, in connection with some maps of work on the Cumberland. These sketches have neither scale nor soundings, and the report that probably accompanied them is not on file in this office.

Capt. R. E. Lee, Engineers, in his inspection report to the Chief Engi-

neer, dated November 20, 1839, a manuscript copy of which is on file in this office, writes as follows:

The dam at the Three Sisters has entirely removed the shoal that formerly existed at this point, and has become strengthened by an accumulation of sand and gravel which renders it permanent.

A breach has been made through the dam at Three Mile Island, through which was the deepest channel at the time of my inspection. It was but partially constructed in 1833 and 1834, and intended to concentrate the water at the foot of the island, from which extended a gravelly shoal. The yielding of the dam still allows its expansion, which would be prevented by its repair and completion.

The effect of the two piers at Scuffletown has been entirely successful in removing the bar at that place, which was formerly one of the greatest obstructions on the river. One of the piers requires to be raised; a beneficial effect has also been produced by the piers at French Island, though in their present condition they but imperfectly answer the purpose for which they were constructed. A settlement has taken place in both piers, which requires them to be raised.

The success of the plan of improvement where it has been fairly tried, viz: The Three Sisters, Scuffletown, and French Island, shows its importance if fully carried out. These were once among the worst points on the river, and they now offer no impediment to the navigation.

In a document on file in this office, issued by the Wabash Navigation Company, dated Vincennes, April 24, 1847, and signed by John Ross, secretary, there is a comparison between the low-water navigations of the Wabash and the Ohio, from which I make the following extracts:

In the report of Lieutenant-Colonel Long, communicated to Congress by the President of the United States in 1843, on the improvement of the western rivers, "about 2 feet water" is assumed as "the utmost that should be aimed at in providing for a general system of low-water navigation." (Doc. No. 2199.) (Not on file in this office.) And in the same report, page 188, Colonel Long states in relation to the Ohio River above and below the Falls, as follows:

"I think the practicability of securing a greater depth (than two feet) in extreme low-water very doubtful if not quite hopeless."

Mr. Burr, (the engineer who made the first report to the company on the lock and dam at Grand Rapids,) in his report January, 1839, p. 8, states: "For three months in the year there is not commonly in the Ohio River, above and below its confluence with the Wabash, for boats over the bars, more than from two to two and one-half feet water, and this season less than two feet."

I have also maps of the bars at French Island, Scuffletown, and Three Mile Island, made by A. Campbell and F. Saunders. These maps are not dated, but, from references to a particular stage of water, I infer that they were made in October, 1844. There is no accompanying report on file, and no information on the map to show what was the stage of the river when the surveys were made. The maps show 3 feet at French Island, 4.2 feet at Scuffletown, and 3½ feet at Three Mile. At the latter place the channel is very intricate, and passes through gaps in the dike. The channel which the dike was to have made is filled with sand, so that the depth through it is but one foot.

This sums up all the information that I have been able to obtain on the practicability of radically improving the Lower Ohio by dikes. Better results could probably be obtained now, as we have additional experience in dike-building, but the possibility of securing by this means 5 feet during extreme low-water, while maintaining a sufficiently wide channel for coal-fleets, is very doubtful if not impossible. If the banks of the Ohio and of all its larger tributaries could be thoroughly protected from abrasion so as to cut off the supply of sand, we might hope for better results; but the expense of such a work is too great for consideration. As land becomes more valuable, greater efforts will be made to protect river-banks, but it will be long before any appreciable effect can be produced on the bottom of the river.

I think that the statements given above will show that the informa-

tion needed to prepare a plan for improving the lower Ohio by controlling the currents can only be acquired by experience. I have already sufficient surveys for all practical work likely to be attempted for several years.

In your last paragraph you ask my opinion about improving the lower Ohio by dredging. I have no hesitation in saying that dredging in the ordinary way would be useless. A dredge could not dig out more than two bars in a season, and the work would probably have to be repeated annually at great cost. A steamboat with scraper would do excellent service, as one day at a bar would suffice, and she could help a dozen or twenty in a season; but the true method of working at bars in light sand is to direct the river-currents on them. There is, of course, a danger that the bar will re-form below, but an extension of the dike will probably drive it away. This system might ultimately result in having continuous dikes throughout the river, but it has the advantage of being the cheapest system that can be adopted, and no more dike-work need be done than the case demands at the moment.

When work was begun at Henderson Island bar the only shoal place was abreast of the island. When I resumed work there this season there was another bar at the foot of the island, which evidently did not exist in 1825. I thought it probable that I would have to build a dike there also, but thus far the single dike at the old place seems to prove sufficient. Colonel Long's dike did not touch either shore. In this it differs from all other dikes ever built on the Ohio. I do not consider the plan judicious, and therefore the dike that I am building starts from the main Indiana shore.

The question of reservoirs may be suggested by some. I can only say that, for reasons given in my annual reports, I consider reservoirs impracticable for the Upper Ohio, and still more so for the Lower. Unless additional reservoirs were built on all the lower tributaries, there would not be a sufficiency of water. The upper reservoirs are expected to give six feet at Pittsburgh. Experience shows that a six-foot rise at Pittsburgh is entirely lost by the time it reaches the falls, unless it is sustained by rises in the lower tributaries. We have no data for determining exactly how much water would be needed to give five feet in the Lower Ohio, nor do I consider it worth while to go to the expense of getting them.

I have recommended for the Upper Ohio locks and dams, with a chute opened and shut by a hydraulic gate. If the dike system does not work in the lower Ohio, we can try locks and dams. The only hesitation I have in recommending it comes from the immense mass of sand that is always in motion below the Falls. Experience in India shows that it is perfectly feasible to build dams on a foundation of pure sand. In the Roorkee Treatise on Civil Engineering, page 494, occurs the following sentence: "Several anicuts (dams) have recently been built with perfect success, and at a moderate expense, across rivers, the beds of which consist entirely of pure sand to a depth beyond the foundation of these works." On page 499, Colonel Baird Smith, Bengal Engineers, in summing up his conclusions about damming sandy rivers, considers the following, (among other points,) as established by Indian experience: "That in rivers with beds of pure sand, and having slopes of $3\frac{1}{2}$ feet per mile, dams may be constructed and maintained at moderate expense; that the elevation of the beds of the rivers above the dams to the full height of the crowns of these works is an inevitable consequence of their construction, and that no arrangement of under-sluices has, as yet, been effective to prevent this result."

We may, therefore, feel assured of the practicability of building such dams, and need now only discuss the question of the moving sands. The only way that I can now see to remedy the difficulty is to give notice that for a given week navigation will be suspended. I would then commence at the lowest pool, and drain it off through the chute. After this was emptied I would let the chute remain open, and drain the next pool through the two chutes, the third through three, and so on. I believe that by this method I would scour a navigable channel through all the pools to the depth of the floors of the chutes.

But the lock and dam system will naturally be tried first in the upper end of the river. Long before it is necessary to start it on the lower river we will have acquired abundant experience on both systems of improvement.

Respectfully submitted.

WM. E. MERRILL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers.

N 3.

RADICAL IMPROVEMENT OF THE OHIO RIVER BY HYDRAULIC GATES AND
MOVABLE DAMS.

Report of the Board of Engineers.

JANUARY 31, 1874.

GENERAL: The board of engineers appointed by par. 1, General Orders 41, Headquarters Corps of Engineers, April 16, 1872, "to examine and report upon the plan of Mr. F. R. Brunot for movable hydraulic gates for chutes and locks, its applicability to the improvement of the Ohio and other rivers, and an estimate of the cost of construction," to which duty was subsequently added, by letter dated May 1, 1872, the general consideration of the whole subject of movable hydraulic gates and of all other proposed plans for this object, would respectfully submit the following report. A preliminary report, dated January 14, 1873, was sent to the Department, in which the board, without specifying any particular plan, stated that there was no doubt of the practicability of attaining the object desired, and recommended an appropriation of \$40,000 for the purpose of testing the matter on the Monongahela. As this report did not reach Congress, no appropriation was made. Since then the board has been actively engaged in studying the history of similar works in this country and abroad, and in testing by large models all the various plans that appeared likely to answer the purpose. They are now prepared to submit a plan which they feel confident will fully meet the necessities of the case.

The special importance of the investigation in question comes from its intimate connection with the slack-water plan for radically improving the navigation of the Ohio. This method of improvement has received the sanction of the great majority of the engineers who have investigated the subject, and it has also been approved by the Ohio River commissioners, a body composed of five delegates, appointed by the governor, from each of the seven States bordering on the Ohio River or its tributaries.

The commercial interests of the Ohio Valley demand that the river shall be so improved as to secure a minimum navigation of 6 feet. There are but two apparent ways of securing such a depth : by retaining in huge reservoirs the surplus of high stages, and letting it out in low ones, and by constructing dams and locks in the bed of the river. There are so many serious objections to the former system, that it has received but little support, either popular or scientific. But a discussion of the merits of the two systems is foreign to this report. The nature of the investigation which we have been required to make presupposes an improvement by slack-water.

The lack of water in the river is, as might be supposed, most marked near its head. In the first twenty miles below Pittsburgh the average fall per mile is 17 inches; in the second twenty miles, 7.7; in the third, 7.8; in the fourth, 8.7; and in the fifth, 10.8. The average per mile of the first one hundred miles is 10.4 inches, and the average per mile from Pittsburgh to Louisville is 6.3 inches. From the foot of the falls to Cairo the average per mile is 3 inches. The method of improvement by contracting the channel, though accomplishing some good, will manifestly not secure the required 6 feet, as can readily be seen by examining the river at White's Ripple and the Trap, eleven miles below Pittsburgh. Here the whole body of water passes through a space whose width at low water is 230 feet, and yet at that stage the depth for navigation is frequently but 12 inches. Whatever improvement may be made, here it is manifestly impossible to secure the depth needed for a successful navigation, if we limit ourselves to guiding the natural supply.

In the Upper Ohio by far the most important navigation is the transport of coal. Pittsburgh annually ships over fifty million bushels to points below, and all the large cities from Cincinnati to New Orleans receive their principal supplies from this source and in this way. Under existing arrangements all this coal comes out on floods of 7 feet or more, a single steamboat bringing down from eight to twenty barges. The representatives of this interest, although not content with the river as it is, would prefer no change, unless it were of such a character that they would have no more delay or trouble in getting their fleets down the river than they have now. Coal-fleets are so large and ponderous, that they require a wide river for maneuvering; and, besides, the barges must be bound together in every direction in the firmest possible manner by cables and screw-clamps. It is very tedious and difficult to make up a coal-fleet, and somewhat hazardous; and it is almost indispensable that, when the boats are once firmly connected, they should remain so until the whole fleet is landed at its destination. For this reason the passage of a lock after the fleet has started is most objectionable, and would cause insupportable delay and danger. The coal-interest of Pittsburgh is therefore a unit in opposing the erection of any dam in the Ohio River, unless some modification can be introduced into the ordinary slack-water system that will permit the passage of fleets without requiring them to be broken up and re-formed below the dams. The slack-water system is undoubtedly very costly, and if opposed by a large class of river-men it would be almost impossible to secure the funds necessary to get it into operation. It may therefore be considered as settled, that the adoption of the system of locks and dams on the Ohio River is dependent upon the practicability of making an opening in each dam of sufficient width to pass a coal-fleet without any delay, of constructing a movable hydraulic gate to open or close this opening at will, and of building a chute or inclined plane of such length and shape that there

will not be an excessive velocity in it nor any objectionable wave at its entrance or its exit.

The average width of a coal-fleet is 125 feet. The least width of chute that can now, in advance of experience, be assumed as necessary is 200 feet. The first question therefore is, can a gate be constructed that can be made to close or open this passage at will.

EXTRACTS FROM HAGEN AND BECKER.

The following extracts from Hagen and Becker, two of the most prominent writers on hydraulics, will show what has thus far been done in this country and in Europe in cases similar to the one with which we have to deal. We will first state that, in order to preserve clearness in the descriptions which we are about to give, all gates turning around an axis fastened to an edge will be called *shutters*; those whose axes are at or near the middle will be called *wickets*.

After discussing generally the uses of movable dams and their importance, Hagen proceeds to enumerate the different plans that have been suggested, prefacing it with the remark that no one seems yet to furnish a full solution of the problem. He then says:

A complete solution of the problem seems to require that the pressure of the water, whether standing or flowing, should furnish the power by which the dam is erected or removed. Or, again, the construction must be such that, notwithstanding the requisite solidity of the structure, it can be managed with a slight power, for which only a few men and a short time are required.

On the improvement, or rather converting into a canal, of the Lehigh River, (Pennsylvania,) which empties into the Delaware at Easton, Josiah White built a movable dam in 1818, which is maneuvered solely by the pressure of the water, and which he therefore called the hydrostatic dam. (Chevalier, *Histoire et description des voies de communication dans les Etats-Unis*, Paris, 1843, Vol. 11, page 464.) It is hardly proper to call them dams, as they really only form the lower gates of locks. Nevertheless the same arrangement is without doubt useful in the construction of an independent dam. Figs. 1, 2, and 3 show a portion of the plan and two longitudinal sections, showing the arrangement of the dam when the gates are opened and closed, taken from the model, as the Wiener Bauzeitung informs us.

The dam is created by a gate which turns on a horizontal axis, and which can be laid flat on the floor. This abuts when it is raised against a second similar gate, whose axis is on the down-stream side. The latter, according to Chevalier's statement, is twice as long as the former, which, however, does not agree with the drawing before us. Both gates close as tightly and firmly as possible against each other, the floor, and both side walls. By this means the pressure of the water under the gates can be increased or diminished by placing it in connection with either the water above or below. The gates rise as soon as the inclosed water receives the pressure from the water above, and lower as soon as the space beneath them is placed in connection with the water below. The two wickets in the side culverts serve for the purpose of creating or cutting off the connections referred to. In order, however, that the gates may not rise too high, projecting strips are applied to both of the side walls, and, in addition, there is a third projecting strip on the lower side of the first gate, which is shown in the drawing. The gates must never rise so high as to become perpendicular to each other, as in this case they could not be dropped.

The lift which is created by this arrangement is in one case 29 feet high, but at the other seven locks it is less. A dam of this construction is said to have been built in the Enz, at Besigheim, in the kingdom of Würtemberg, with complete success.

Hagen then mentions a plan of movable dams which has been proposed. It consists of placing boxes or caissons alongside of each other, which are loaded in such a manner that at low stages of the water they will firmly settle to the bottom, but when the water reaches a certain point they will rise and float off. He says of this:

The difficulties of executing this plan, especially in swift water, appear, after careful consideration, so great that, as far as is known to me, no attempt has yet been made to apply this idea to dams in rivers. At dry-docks, arrangements of this character are in use, but in these cases there is no current, either in placing or removing them, since the water on both sides is at the same height.

He then gives a description of a dam on the principle of the one suggested by General Moorhead. He says:

Other dams are so arranged as to fall when the pressure of the water increases. The wicket-gate with horizontal axis is an example of this class. The gate or wicket, when closed, rests at its lower end against a shoulder in the top of the dam. As long as the water above is below the horizontal axis of the wicket, its pressure increases its stability. But when the water rises above the axis, a counter-pressure is created. Both of these pressures only become equal (provided the down-stream water does not touch the wicket) when the up-stream water stands twice as high above the axis as this is above the top of the dam. If the water rises higher than this, the pressure on the upper part of the wicket becomes greatest, and it falls.

Figures 4, 5, 6, and 7 show a dam with this arrangement in the Riom, in the department of Puy de Dome. (*Annales des Ponts et Chaussées*, 1842, I, page 231.)

There are three openings in this dam, each 12 feet 9 inches in length; the wickets, consisting of a double layer of planks, are 2 feet 3 inches high. They extend into the abutments, where they turn in recesses whose edges support the wickets and diminish the leakage, besides preventing the wicket from turning down too far. The other peculiarities of this arrangement are shown by the drawings; but it must be borne in mind that when the water falls the wickets do not raise themselves, but must be lifted up from the abutments by means of hooks.

Similar turning gates or wickets may be held in an upright position by means of hanging weights. At high stages these counterpoises are submerged, and their loss of weight causes the wickets to fall down; when the water falls the weight of the counterpoises is restored and the gates are raised.

This arrangement has been practically applied ever since the year 1834, in the improvement of the Ouse above York. (*Civil Engineering and Architects' Journal*, 1840, III, page 284.)

The Ouse was formerly navigable only as far up as Selby. Farther up to York the depth on several gravel-bars at low water was only 5 feet.

To navigate this portion of the river it was, therefore, necessary to await the spring freshets, and the larger class of ships could not get up at all. After several of the gravel-bars had been removed by dredging a depth of from 11 to 12 feet was obtained at high water.

After this it was decided to extend the navigation of the river 20 miles farther up, to Borough Bridge.

A number of locks and dams already existed on this part of the river; but the depth of water in the intervening pools was not sufficient, and it was impossible to raise the dams on account of the low banks of the river. Nevertheless, at low stages in summer it was possible to raise the surface of the water 18 inches. This purpose was subserved by the wicket arrangement just described.

Two wickets of this kind, each 74 feet long, 18 inches wide and 4 inches thick, constructed of pine wood, constitute the movable portion for increasing the height of the dam, whose whole length is 148 feet. They stand upon the top of the massive dam, and are held at every ten feet by strong iron hinges, let into and fastened with lead to hammered stone, which permit them to lie flat on the top of the dam. The movable arm of each hinge ends in a pin 1 inch in diameter, which projects above the wicket. To these pins flat chains are fastened, which wind up on an equal number of eccentrics. The latter are attached to two iron axles, each of which has the same length as the corresponding wicket. These axles rest on iron chairs, which are placed on the up-stream slope of the dam. Next to each of the abutments a cog-wheel is attached to the axle. This cog-wheel is driven by another wheel, which latter is connected with a pulley from which the counterpoise hangs.

When the counterpoise rests upon the abutment the wickets stand in a perpendicular position. This is the case as long as the water does not rise above 6 inches over the wickets, or 2 feet over the top of the dam. When the water rises above this point its pressure upon the wicket gains the ascendancy; they lie flat upon the dam, and their influence upon raising the water is completely destroyed. As soon, however, as the water subsides, the counterpoise sinks, and the wickets resume their upright position. This arrangement was proposed and carried out by Engineer Rhodes, and it is said to have given results in every respect favorable.

Hagen then goes on to say:

Another ingenious arrangement of such wickets on dams was executed by Engineer Thénard, on the River Isle, in the Département de la Dordogne. It not only possesses the advantage of the one just described, in that the shutter falls flat upon the top of the dam, but it possesses besides the superiority in this, that no chairs or other parts of the apparatus project, and that, therefore, the greatest ice-field can pass over it without causing any damage. The raising and lowering, it is true, is not caused by the rise and fall

of the water itself, but the attendant must, by means of a mechanism which he controls from the shore, sever certain connections. There is, however, no disadvantage in this, as the employment of an attendant is already necessary at that point on account of the lock. The movement of the shutter is caused, however, by the pressure of the water, and results at once, without the application of outside forces. These movable dams were partly constructed in 1823, and finished in 1832. In the report of the commission which examined them in 1841, no mention is made either of injuries or repairs, from which it must be inferred that such did not occur to any noteworthy degree.

Figures 8, 9, 10, and 11 show one of these dams, the elevation looking down stream, the plan, and two sections. The whole length of the dam is 151 feet; at one end there is a lock and two sluices. The dam is created by the down-stream shutters, which fall down stream. When they are raised, as figure 10 shows, they are held in position by iron props which abut against iron plates on the top of the dam. It is only necessary to trip these props, and the shutters fall down under the pressure of the water. For this purpose an iron rod (figure 12) is used, which extends lengthwise over the dam, and is provided with teeth at one end, which are grasped by a cog-wheel. This cog-wheel is put in motion by a lever which is attached to its axle. The props are not tripped at once, but in succession, a different one being tripped each time that the bar advances $1\frac{1}{4}$ inches. This is accomplished by means of projections on the iron rod, whose distances apart are a little greater than the distances between the props. The drawing back of the rod before the shutters are again set up is accomplished by the same machinery.

The raising of the shutters against the pressure of the water would, however, be very difficult if this pressure could not be removed while doing so. The counter-shutters, which fall in the up-stream direction, are used for this purpose. They generally lie flat, both in high and low water, and grasp, by means of a spring-latch, a catch which is fastened to the top of a post in front of each. These latches can be moved in the same manner as the props which sustain the lower shutters. As soon as one of them is sprung the water from above raises the counter-shutter as far as the chains will admit. When all the counter-shutters are raised the water is dammed, and several minutes intervene before it flows over. During this interval the lower part of the top of the dam is dry, and the attendant has the opportunity, without the least danger, to descend by means of a ladder, and to raise each section of the dam in succession, replacing its prop in its proper position. The operation is begun on the side from which the attendant descends, and is continued to the other side. He then waits until the water flows over the upper edge of the counter-shutters, and the real shutters become the dam. As soon as this occurs the pressure ceases against the counter-shutters, and they can be easily and rapidly pushed down in succession by a pole, so that the spring-latches again grasp the catches and hold them firmly.

The commission which examined this construction on the Isle expressed the opinion that these shutters could safely be made from 3 to 4 feet high, but in the latter case it would be well to limit the length of the sections to $3\frac{1}{2}$ feet.

Hagen then mentions that movable dams have been constructed which turn around vertical axes like lock-gates. The axis is placed either in the center of the gate or near it. They are maneuvered by means of valves in each leaf, assisted by machinery. The advantage is that as the gates are high the machinery for turning them can always be used. The disadvantages are that they can only be made of narrow spans: that, when open, they stand in the stream, and are exposed to destruction by ice and drift; and that, when closed, only the larger leaf can be supported, the pressure of the water having a tendency to move the other leaf away from any support that might be constructed for it.

He then mentions another form of movable dam; this consists in laying a sill in the bed of the river, and swinging, just above this, a beam from abutment to abutment, and then placing, by hand, small scantling, which he calls "needles," resting against the sill below and the beam above. This plan has been practiced in France for many years.

A great improvement on this plan was made by the French engineer Poirée a short time before 1840.

The improvement consists in this, that instead of having a single swinging beam for the whole span, this beam consists of different pieces resting upon movable trestles. The first dam of this kind is in the Yonne, just below the mouth of Bourgogne Canal, near the village of Epineau. Soon after (in 1840) a similar dam was built in the

Seine, near Paris. The result of both, so far as it is known, seems to have been satisfactory in every respect; and since that time they have been erected in many other streams in France, with frequent alterations, however, in their construction.

The following is a description of the first one erected, (near Epineau:)

The movable portion of this dam is 223 feet long. Its masonry-floor has (as Fig. 13 shows) a width of nearly 32 feet, and is 15 $\frac{1}{4}$ inches below the lowest stage of water in summer. The floor is about on a level with the natural bed of the river. The masonry of the floor is on an average about 4 feet thick. A recess, 7 feet and 3 inches in breadth, extends lengthwise along the floor. In this the wooden frame which supports the movable iron trestles is laid and firmly wedged.

The whole arrangement is shown in figures 14, 15, and 16. The edges of the recess are not vertical, but inclined, the width on the bottom being greater than on top. On the down-stream side a wooden sill of corresponding form rests against the edge of the recess. The rest of the recess is then filled by a horizontal wooden frame, which is bound together at intervals of 3 feet 2 inches from center to center by braces mortised and tenoned into it. In the space between the sill and this frame double wedges are driven at intervals of 6 feet 6 inches, by which the whole wooden frame is held in the recess.

This manner of fastening is so simple that it is not necessary to draw off all the water in order to take out or replace the frame. According to Chanoine, this can be done without difficulty in a 3-foot stage of water.

In later constructions the sill is entirely abandoned, the down-stream side of the recess being made vertical and of cut stone, so that the frame may be firmly wedged against it.

On the inner side of the longitudinal beams of the frame, and immediately over the center line of each brace, are laid the iron collars wherein the axles of the trestles turn. These collars are so arranged that the trestle may be taken out and replaced under water. Figure 17 shows the elevation of the up-stream collar. It is simply supplied with a round hole into which the axle is inserted. The opposite collar, however, (Fig. 18,) has, besides the hole in which the axle lies, a slot at one side enlarging upward, down which the axle must be shoved, and which is then closed by an iron plug. The iron trestles do not, however, rest entirely on these collars, as their axles touch the braces just below them, and a part of the weight is borne by the latter.

The trestles, nearly 7 feet in height, are constructed of bar-iron, jointed and riveted, except the upper end of the strut, which is held by a screw. The bar-iron is 1 $\frac{1}{2}$ inches in thickness, and also in width. The weight of each trestle is such that two workmen standing on the foot-bridge can easily raise it by means of the chain. This chain is fastened to the ring which projects from the head of the screw above referred to. But this chain is in no wise indispensable, for an experienced workman can easily grasp the upper beam of the trestle and raise it into position. It is, therefore, customary during winter to remove the chains, because they are frequently caught by drift, and then are not only subject to injury themselves, but are apt to retain such objects at the dam, and cause heavy deposits of gravel.

In constructing the dam, each trestle is raised by the attendant and his assistant; as soon as it is nearly vertical, and only moderate strength suffices to hold it, the attendant leaves this part of the business to his assistant and seizes the trestle at the upper bar with the forward notch of the hook, (Fig. 19,) and then places the rear notch upon the last trestle raised, which is now firmly established. The foot-bridge is then extended by laying three short planks, about 4 feet in length, alongside of each other, and so far forward that they have a firm hold upon the newly-raised trestle. Through a notch in the planking a strong pin fastened to the upper bar of each trestle extends above the floor. This is partly to serve as a guide for properly laying the planks, but mainly as a firm point against which the attendant can brace his foot during the operation of raising the next trestle.

As soon as the planks are laid, two iron clamp-bars, one inch in thickness and nearly two inches in width, provided with two notches, (see Fig. 20,) are laid upon the last two trestles, after which the hook which temporarily held the last trestle in position may be removed. One of these iron clamps is laid on the up-stream side of the heads of the screws, and forms the upper bar against which the "needles" or scantling rests. The other, which need not be so strong, and is often entirely omitted, rests, if it is used at all, upon the down-stream corner of the trestle.

In this manner the whole of the frame-work may be erected by two men, although it is generally customary to employ a third laborer to carry the planks and the clamps. The removal of the dam is carried on in the inverse order, and needs no description. It must be remarked, however, that it is not necessary to raise up or lower all of the trestles, as each one, when it once has its full connection on one side, is perfectly safe. It is, therefore, quite easy to make an opening at one end of this dam for passing vessels. The last trestle lies as flat as the rest in an opening provided for that purpose in the massive abutment.

Iron bars, projecting above the floor of the bridge, are fastened on the outside to the top of the posts of each trestle; but, in order to preserve clearness, they have not been indicated in the drawings. The one on the up-stream side is only a few inches high, and serves partly to prevent the clamp-bar from clipping off, and partly to hold the last "needle" in case this trestle becomes the end of the dam. The iron bar at the other side rises about one foot above the foot-bridge, and is also partly for the purpose of holding the other clamp-bar, but mainly to serve as a rest against which the "needles" are piled during the course of constructing or removing the bridge.

The "needles" are made of straight-fibered wood, and are 7 feet 9 inches long, 2½ inches broad, and 1½ inches thick. They rest at top against the clamp-bar above mentioned, and at bottom against the up-stream longitudinal beam of the frame, into which for this purpose an iron bar is let. In front of the axle of each trestle this iron bar has a small projection, which holds the lower end of the "needles" in the same manner as the top is held. The attendant thus has a guide at each trestle, by which he can keep the "needles" in the proper position.

The cost per running foot of this dam, including foundations, abutments, and all appurtenances, was 175 thaler, (\$12½.) After a few attempts it required 32 seconds per running foot to take down the dam, and 57 seconds per running foot to erect it. But it was soon shown that the work was done more rapidly as soon as the attendant had more experience.

It is undoubtedly a question of great importance to ascertain how this dam will act during high-water, and whether it will not cause large deposits of sand, which will make it difficult to raise the trestles, and therefore necessitate the resort to extraordinary measures for this purpose. From all information which has become public, and from what could be learned from private inquiry, it seems that these fears are unfounded. Chanoine says that it is true that the recess is sometimes filled up with deposit, but that even then the trestles can easily be raised or lowered if they are first worked up and down a little, so as to loosen the deposit, and cause the current to carry it off. The deposit that remains in the recess is, according to the same authority, easily removed by forcing a rapid stream of water over it, and for this purpose the dam itself furnishes every facility. It is only necessary, after the dam is constructed, to remove a few of the "needles" at the point where the scouring is to be done. In this manner there is no difficulty after the whole structure is erected in completely clearing the foundation and recess. Even if the trestles were found so completely covered that they could not be lifted by either the chain or hook, the proximity of the already constructed portion of the foot-bridge would allow the easy removal of the deposit by hand-scrapers, and thus permit the trestle to be raised.

It is besides probable that in such a case this difficulty would be removed by putting the "needles" in place as far as the foot-bridge is constructed, as by this means the rapidity of the current would be so much increased that it would remove the deposit from the trestles that were buried. The conditions are precisely the same as in building a wing-dam, or dike. The portion of the dam already erected is nothing but a perpendicular wing-dam with a very steep face, and precisely as such a work under other circumstances causes a great scour at its outer end, so in this case will it remove the gravel and sand from the foundation of the dam.

In some instances, as in the Saône, between the Rhine-Rhone Canal and Lyons, the arrangement just described does not form the entire dam, but is only an addition to the permanent structure, which in this case rises to ten inches above the lowest stage of water. (*Annales des Ponts et Chaussées*, 1845, I, page 10.) In this arrangement there is undoubtedly no trouble with deposit, or at furthest only with that which the recess contains. But even this cannot occur here, as the foot-path consists of iron plates fastened to the upper bar of the trestles in such a manner that it lies down with the trestles, and thus makes a cover which effectually closes the recess and conceals the whole apparatus. The details of this arrangement are thus far unknown.

A great advantage of this dam is that the stage of water can be kept at any point in case of rises by simply removing a proper number of needles. It is advantageous, however, not to make this opening at one point alone, but to make numerous openings uniformly distributed along the whole dam. The attendants are able to judge with great accuracy in this matter, so that it is not necessary for them to make continual experiments, but they are immediately able to tell how many needles it is necessary to remove for any rise.

When the water below the dam is high, with a strong wind up stream, there is danger that the waves may lift the foot-path from its position and carry it away. This evil is averted by drawing the chain diagonally across the foot-bridge between the successive trestles.

The erection of the trestles and the placing of the "needles" does not generally require haste, as the low-water stage of rivers and streams generally comes gradually. On the other hand, rises, especially in mountain streams, (where these dams are generally used,) often occur suddenly, in which case the arrangement just described for removing the "needles" is not as rapid a maneuver as the circumstances require.

This is particularly the case when the rise occurs at night, because then the work is delayed by darkness. Provision for the convenient and safe use of lanterns must naturally be made, but the lifting out of the "needles" may be avoided, and the stream may be made to push down the sections between the trestles, if the iron clamp-bar is arranged in the same manner as the turning-beam above described. This arrangement is made at the dam in the Seine at Saint Morton. (*Annales des Ponts et Chaussées*, 1843, I, page 250.) Each needle is provided with a strong ring at its handle. A line is tied to the ring of the "needle" next to each trestle, and passed through the rings of every "needle" in that section and then fastened to a strong hawser which reaches the whole length of the dam. In this manner all the "needles" remain hanging in bundles when the trestle is lowered, and as only one end of the hawser is fastened they are driven against the bank; afterward they are easily loosened and carried to the store-house.

The clamp-bar must be arranged differently from the manner above described if it is to be loosened when the "needles" are still pressing against it. The arrangement is quite complicated, and is made more so by the necessity of guarding against all accidental or malicious movements which would result in the opening of the dam. I will describe here only the material part of the arrangement. Figs. 21, 22, 23, and 24 show it in plan, and in front and side elevation. The clamp-bar has, in every instance, a hook $2\frac{1}{2}$ inches broad and 1 inch high. At one end it is provided with a hole, through which passes a pin which projects above the trestle. At the other end the hook is bent into a cylindrical form, which grasps the pin on the trestle. The front side of the hook forms an even surface, against which the "needles" rest.

To prevent the hooks from being loosened by the pressure of the "needles" there is an eccentric disk, which turns around the shank of the ring previously mentioned, to which the chain for raising the trestle is fastened. Figures 21, 22, and 23 show the eccentric disk in the position in which it holds the hook. In Fig. 24 it is turned so far that the hook no longer takes hold and the trestle may be laid down. Before the eccentric is turned into this position the trestle must be held by the light hook (Fig. 19) until the foot-bridge can be removed. The position of the eccentric disk is finally fixed by a key, which must be raised whenever it is to be turned. If the latter is in such a position that the eccentric disk is clear, as is shown in Fig. 24, a blow on the point of the disk will cause it to turn, and the pressure of the "needles," which is transferred to the hook, will complete it. The hook, however, is removed before the trestles are allowed to fall.

Finally, it must be stated that the abutments at St. Morton are not provided with recesses, but that the last clamping-bar, whose length is equal to the height of a trestle, turns on a vertical axis and is held in its position by a brace. It rests flat against the wall when the dam is lowered.

Becker also speaks of the great importance of movable dams, and then gives a description of several kinds already constructed, all of which, except one, are given by Hagen. This one is a combination of the systems of Thénard and Poirée. He says:

The systems of Thénard and Poirée can be combined with advantage to form a system peculiarly adapted for sluices which must be rapidly opened, or which are regulated by the water itself and need no attendance. Figs. 25, 26, 27, 28, and 29 show the construction of such a dam as it is built across the Seine, at Courbeton, in the vicinity of Montereau. A needle-dam, 124 feet 8 inches in length, abuts against the tail-wall of a lock. To carry off the surplus water in high stages, a sluice 39 feet 4 inches wide suffices. This sluice was, therefore, built according to this mixed system, and is separated from the needle-dam by an abutment 3 feet 3 inches thick.

When the sluice is closed, the shutters, Figs. 26, 28, and 29, are raised, and the iron trestles of the dam are also raised, and serve as support for the planks of a foot-bridge. The needles are not used.

When the water rises it flows into a culvert in the shore abutment, and thence to a small water-wheel 5 feet 3 inches in diameter and 20 inches wide. (Fig. 26.) On the axle of this wheel there is a bevel-wheel, which works into another bevel-wheel, on whose axle there is a rectangular cog-wheel which works into another wheel, whose axle is vertical and reaches down to the foundation of the dam. At the lower end of this axle there is another cog-wheel, which works into the toothed end of a rod, (Fig. 27,) whose motion, in a longitudinal direction, causes the successive falling of the shutters.

As soon as enough shutters have fallen to reduce the water to its former height, the water-wheel stops, and no further opening of the sluice takes place.

At high-water the effect of the water upon the water-wheel only ceases when all the wickets are down.

From this it is easily seen how the stage of water regulates itself, and prevents a flow over the top of the needle-dam.

If it is desired to raise the shutters after the subsidence of the flood, the lock-tender places the "needles" in position, and thus constructs a protection, behind which he can raise all the shutters, with ease, by hand.

After the shutters are all raised the "needles" are again removed, and the planks of the foot-bridge replaced, in case they were removed during the high stage of the water.

Should the water-wheel remain in motion longer than is necessary for the complete movement of the iron rod, there is an arrangement attached to the mechanism by which the pinion that moves the rod is thrown out of gear. (*Annales des Ponts et Chaussées*, 1851-'52.)

METHODS IN USE IN INDIA.

The arrangement of double shutters, shown in Figs. 8, 9, 10, 11, and 12, has been successfully used in Orissa, in India, on the ancient or dam across the Mahanuddy River at Outtack. The following description is taken from the Roorkee Treatise on Civil Engineering, volume ii, paragraph 703 :

Instead of the small sluices provided as in the Kistna, and other anicuts, a larger kind of sluice, on the French pattern, has lately been successfully employed on the Mahanuddy anicut in Orissa.

The center sluices are divided into 10 bays of 50 feet each, by piers of masonry. Each bay is closed by a double row of timber-shutters, which are fastened by wrought-iron bolts and hinges to a heavy beam of timber imbedded in the masonry floor of the sluices. There are seven upper shutters, and seven lower or rear shutters; the latter are 9 feet in height above the floor, and the former 7½ feet.

During floods, therefore, the upper row of shutters, which fall forward, is fastened down by clutch-gearing in an almost horizontal position, while the rear set of shutters, which fall backward, is kept during flood in a horizontal position by the water rushing over.

During the summer season these rear shutters have to do the duty of damming up the water, and for this purpose they are provided with strong wrought-iron stays or struts attached to them behind or on their lower side. As it would be almost impossible, however, to lift these back shutters with a depth of 5½ feet of water tearing over them, the upper shutters are so constructed as to render this a matter of comparative ease. As the upper shutters point up stream, the natural tendency of the powerful current passing over is to lift them up. By simply unclutching them, therefore, they immediately rise and dam up the water, being retained in position by two sets of chains, which take the strain off the hinges. The water being thus dammed up, the back shutters are easily lifted, and permit in their turn of the upper shutters being lowered forward into their horizontal position.

The superintending engineer, Mr. Walker, in reporting on them, considers it is established—

1st. That, with the shutters constructed on the French pattern, and with a head or pressure of between five and six feet, 500 linear feet of shutters can be easily lowered in one hour.

2d. That, under the same condition, an equal length of opening can be closed in 25 minutes. In closing, the shutters may be said to be self-acting.

3d. That when the back-stays are released, the falling shutters are received upon a cushion of water in time to prevent any undue concussion.

4th. That the action of the water in lifting the upper shutters brings no excessive jerk on the chains, but that it is advisable that chains have an adjusting-screw fitted on, so as to make the strain perfectly uniform. The shutters were brought home in a current of 10 feet per second.

5th. That three men can knock away the back-stays with a pressure of between five and six feet with ease and security.

6th. That twelve men are necessary to lift each of the back shutters into position.

An immense dam, two and one-third miles in length, is now in process of construction across the Soane River at Dehree, where it emerges from the Kymore hills and enters the plains of Behar, through which it flows sixty-five miles to its junction with the Ganges. At each end of the dam, and at its middle, under-sluices are provided in order to prevent an accumulation of alluvial deposit above the dam. Those at the ends are especially designed to keep clear the heads of the irrigation-canals which start at each bank, and take their water from the pool formed by the dam.

The sluice-gates are to be made on the double-wicket plan, with some modification, and the following description is taken from the London Engineering, vol. xvi, p. 219:

We proceed to give a short description of the self-acting shutters invented by Mr. Fouracres, which are used to open or close the under-sluices in the wear. We have already stated that there are three sets of sluices, of 25 openings, of 20 feet in each set, and that only in times of flood, and in order to scour out any deposit which may be formed opposite the lock-entrance on either bank, are they required to be opened. The usual practice in works of this kind is to have small openings of six feet in width, with a roadway overhead, the openings being closed or opened by gear from the top, but it was found by thus diminishing the size of the passages, the efficiency of the scour was also considerably diminished, and moreover openings of that size were unable to pass through them all the large timber, wrack, and brushwood which an Indian river brings down in times of high flood. It was therefore attempted, in Orissa, to increase considerably the size of the sluice-openings in the wear in the Mahanuddy River, and shutters on the plan adopted by French engineers in the navigation of the Seine were constructed.

The objection to this plan was that the upper shutter was raised by the stream with such velocity and force that the chain-ties supporting it frequently gave way, and the shutter was carried off its hinges. It was also necessary that the shutter should be self-acting, as to opening itself to let a flood pass through the sluices, and it was to meet these two requirements that Mr. Fouracres's self-acting shutters were invented. Figs. 30, 31, and 32 show three views of these shutters in different positions, and Figs. 33 and 34 show two sections which will further assist in explaining the arrangement.

Fig. 30 shows the sluice "all clear," with both shutters down, lying on the floor, the floods being supposed to be running freely between the piers, which are 8 feet in height. When it becomes necessary to close the sluice, and shut off the water flowing through it, a clutch worked from a handle from the top of the pier is turned, which frees the shutter from the floor, and it then floats partially up from its own buoyancy, when the stream, impinging under it, raises it to an upright position with great force, shutting up the sluice-way. But if a shutter 20 feet long were allowed to come up with such pressure it would either carry away the pier or be carried away itself. To destroy this shock, Mr. Fouracres has contrived six hydraulic buffers or rams, which also act as struts for the shutter when in an upright position. These rams are simply pipes with a long plunger inside; (see enlarged section, Fig. 35;) the pipes fill with water when the shutter is lying down, and when it commences to rise the water has to be forced out of them by the plunger in descending, and as only a small orifice is provided for the escape of the water, the ascent of the shutter forced up by the stream is slow and gentle, instead of being violent.

The water is now shut off effectually, as shown in Fig. 31, but, without other means being taken, it would be impossible to open the sluice again, as it could not be forced up stream. Another shutter is therefore provided below it, as shown in Figs. 32 and 34, this lower shutter being arranged so that it can be lifted up by hand and placed upright, as shown in Fig. 32. The water is then allowed to fill the space between the two shutters, and the upper one can then be thrown down on the floor again, but the lower one is held up by ties which are hinged to it at one-third of its height, and by this means it is balanced, and resists the pressure on it until the water rises to its top edge, when it loses its equilibrium and falls over, thus opening the sluice again. The shutters can be left to fall of themselves if the river rises in the night, or, if it is not thought expedient to let them fall, they can be made fast by a clutch on the pier-head, as shown. By these expedients these large sluice-ways, 20 feet broad and 8 feet deep, can be shut off or opened as required, with the greatest facility and expedition, and the whole set of 25 sluices can be opened in a few minutes, and when opened they can pass through them anything that the river brings down without danger to the wear. It has been proposed to bridge over the piers with a light iron foot-bridge to enable a man to work the clutches of the shutters more easily.

It will be seen from the above that in the sluices of the Mahanuddy dam the openings are 50 feet in width, and are closed by seven shutters of each kind, giving a width of a little more than 7 feet to each shutter, while in the Soane dam each opening is 20 feet wide and is closed by a single shutter.

CHANOINE WICKETS.

In the *Annales des Ponts et Chaussées*, tome 2, 1861, there is a very complete memoir on one kind of movable dams, prepared by M. Cha-

noine and De Lagrené, of the Corps des Ponts et Chaussées. This memoir gives a full detailed description of what is known as the Chanoine system of wickets.

It should first be stated that the dams, principally on the Seine and Yonne, to which these wickets have been applied, consist of a lock, a pass for navigation whose sole is about even with the bottom of the river, a pier, a weir whose sole is about $3\frac{1}{2}$ feet above the river-bottom, and an abutment.

The Chanoine wickets are shown in Figs. 37 to 45. Figs. 37, 38, and 39 represent the wicket of a navigation-pass; Figs. 40, 41, and 42 the wicket of a weir; and Figs. 43, 44, and 45 show the manner of raising the wickets by a boat, provided with a windlass and other suitable equipments.

The Chanoine wickets are of two kinds, automatic for the weir and non-automatic for the pass for navigation, or chute. They differ from the shutters previously described in having the axis of rotation at from one-third to five-twelfths the vertical height from the foot of the wicket. This axis is supported by a small iron horse, which is itself movable up and down stream around its foot. The head of the prop rests on a pin, passing through boxes fastened to the cap of the horse, and its foot rests against a hearter. To throw down a wicket the foot of the prop is pushed away from the hearter by the projections of an iron rod worked from the abutment. These projections are so spaced that the wickets are thrown down in succession. This arrangement is adopted from the Thénard system, which has already been described. To permit this movement, the hole at the head of the prop is larger than the pin which connects it with the horse.

The wickets for the navigation-pass are hinged at five-twelfths the vertical height from the bottom, and are provided with a fixed counterweight at the foot. In vertical height they vary from 8 feet 10 inches to 10 feet 2 inches, and when in position are inclined down stream under an angle of 15° . The portion of a wicket above the axis of rotation is called the *chase*, and that below the axis the *breech*.

The wickets of the weir are smaller than those of the pass, and are hinged at about one-third the height above the bottom, so that when there is a flow over the top of more than 8 inches in depth, the pressure above the axis of rotation exceeds that below it, and the wicket swings into a position nearly horizontal, thus opening a passage for the water. The weir-wickets are provided with movable counterpoises, in addition to the fixed ones, with the expectation that after being swung they will close of themselves when the water recedes. As will be found further on, this arrangement did not work satisfactorily. These wickets, like those of the navigable pass, could be tripped by an iron rod, worked from the abutment, whenever a great flood made it desirable to throw them down flat, on the top of the weir. It was not thought desirable to make the wickets of the navigable pass automatic for fear lest they should be thrown down by floating bodies, which might become entangled, and, by preventing the wicket from lying flat, make a dangerous obstruction to boats.

The wickets of the weir varied in height from 5 feet 5 inches to 6 feet 7 inches, and their axes were placed about an inch and a half higher than one-third the total height above the sill. All wickets are made about 4 feet wide to facilitate maneuvering.

To raise the wickets a boat 30 feet long and 8 feet wide was used, which was worked from above the dam, and was provided with ropes, fenders, and windlass. To raise the wicket nearest the bank the boat

was placed along the upper side of the abutment, at right angles to the current, with its bow projecting half the width of a wicket. By means of a boat-hook the attendant seized the handle on the lower end of the wicket. As soon as this was done his assistants commenced winding in a rope, fastened to the lower end of the boat-hook, and passing thence around a pulley in the bow to the drum of the windlass. The wicket was thus raised into a horizontal position, and the current pressing down on the breech swung it into place. As soon as one wicket was raised the boat was pushed forward the width of a wicket, and the operation was repeated until the pass was entirely closed. There is always an interval between the wickets of a little less than two inches, and by inserting keys in the intervals between the wickets already raised, and by using fenders and a cable fastened to the abutment the boat is securely held in place throughout the maneuver. The wickets of the weir are raised in the same way.

COMPARISON OF THE POIRÉE, CHANOINE, AND DESFONTAINES SYSTEMS.

In tome xi, *Annales des Ponts et Chaussées*, 1866, M. de Lagrené, engineer des Ponts et Chaussées, makes a comparison of the different methods of constructing movable dams, and the following is an abstract of his article :

At the present moment dams are in course of construction, not many miles apart, that differ essentially ; thus on the Seine, below Paris, the needle-dam, invented in 1833 by Inspector-General Poirée, has been adopted ; above Paris the dam with movable wickets, invented in 1852 by Chief Engineer Chanoine, has been chosen ; while on the Marne the movable dams of the Upper Seine are used, but under different conditions, and with the addition of the drum-wickets invented in 1864 by Inspector-General Desfontaines.

These three systems are those which he compares. As the Poirée needle-dam has been fully described already, also the Chanoine wickets, only his conclusions will be given in regard to these two systems, but a full description will be given of the Desfontaines drum-wickets, (*hausses à tambour*.)

The Poirée needle-dams were first designed for heights of 5 feet, but they have gradually been heightened to 10 feet 10 inches.

And as, in fact, a dam on any system whatever is always an obstacle to navigation, it was natural to limit their number as much as possible, and, in consequence, to give to each one the greatest height compatible with its location and details of construction.

It will at once be understood that if a sudden flood should come, or even a simple artificial wave, the foot-bridge for managing a needle-dam might be submerged before there was time to remove the needles, and serious accidents might happen either to the dam, to navigation, or to riparian property. An endeavor was made to avoid this danger by means of a permanent weir connected with the pass, having a needle-dam ; thus at the Epineau dam, whose pass is 230 feet wide, with a sill 16 inches below low water, M. Poirée added a masonry weir 403 feet long, raised to 3 inches below the level of the pool ; at the Bezous dam, consisting of an open pass 158 feet in length, with its sill 24 feet below low water, and a higher pass 155 feet in length, with its sill 16 inches below low water, a permanent weir has been added 1,411 feet in length, and at an elevation of 16 inches below the level of the pool ; but such a weir, admissible for small lifts, becomes very costly when the lifts are great. Moreover, in certain cases, the submersion of the needles and trestles can still occur in spite of it.

To diminish the danger of submersion, while at the same time avoiding the cost and inconvenience of a permanent weir, and also to facilitate navigation by artificial waves, the bars that support the needles have been arranged so that the lock-tender can easily disengage them. The needles of each bay are then carried away by the current, as the lock-tender successively opens the bays ; but as the precaution is taken to fasten them to ropes, they are easily fished up from below the dam.

At the dams on the Yonne the escapement consists of an eccentric which permits the opening of 131 feet of pass in 15 minutes, while an hour used to be required with the old arrangements.

The Belgian method allows the needles of each bay to escape in a body, but the trestles remain standing. The French method drops each trestle as the needles attached to it are loosened. By the Belgian escapement the heads of the needles must pass under the sheet-iron floor of the foot-bridge. The disadvantages of this arrangement will be shown presently. The employment of escapements does away with the necessity of raising the needles by hand, and thus permits the construction of higher dams.

METHOD OF MANEUVERING A NEEDLE-DAM.

Let us recall in a few words how a needle-dam, furnished with escapements, but without permanent wear, is managed.

Suppose it to be entirely closed. If the discharge is nearly that of low water, the filtrations between the needles can be reduced by throwing in grass just above them. If a rain should come sufficient to raise the level of the pool, the attendant makes a sufficient number of openings in the part of the dam farthest from the lock, by removing only a few needles from each bay, so as to divide the issuing current. As the discharge diminishes, the attendant gradually replaces needles that have been removed. When the rainy season approaches, the dam is prepared for opening. With this view he passes the ropes through each group of needles yet remaining between the trestles, and fastens them to the shore in the customary manner, and as soon as the lift of the dam is reduced to a height determined beforehand, he looses the escapements and lowers the trestles in succession, satisfying himself as he goes on that each one is well down and makes no projection on the floor. The same method of opening is used on the arrival of an artificial wave on the rivers where this method of navigation is in use. This maneuver must evidently be made at night as well as during the day, and, besides, the trestles must be laid down in winter, as soon as the first ice-cakes form. When the opening is completed the attendant can fish up at his leisure the needles which are floating below the dam at the end of the cable.

When the high-water season is passed, the attendant piles up the needles upon the walls, and prepares to raise the trestles; this raising is done when the water-surface has fallen to a previously determined level; the attendant then raises all or part of the trestles, places a few needles at intervals, and gradually increases their number so as to obtain and preserve the normal level of the pool.

OBJECTIONS TO NEEDLE-DAMS.

A needle-dam is evidently, as has been already shown, a work by means of which the level of a pool is regulated at will, and very simply, by removing or adding a certain number of needles, provided always that the placing and the removing or loosing of these needles cause neither danger nor too severe an exertion. It, therefore, seems to us that when the height of the lift is slight, these conditions are only partly fulfilled, and that they are not fulfilled at all when high trestles are in question. This is the case which we propose examining.

When the trestles are more than 8 feet high the needles assume such dimensions that their transportation from the store-house to the place where they are used is quite burdensome, (the Bezons needles are 13 feet in length and 3 inches square,) and their placing becomes dangerous and difficult, as much on account of their length and cross-section, as in consequence of the depth of the water, and its velocity. If a needle does not strike the sill against which it ought to abut, the attendant may be dragged overboard by it. Their removal by hand becomes impossible if the difference of level is great, and it is then necessary to resort to a system of loosing the supporting-bars, or to pull the needles one by one by means of a windlass. (A needle 13 feet long and 3 inches square weighs 20 lbs. when it is dry, and 29½ lbs. when it has remained in water.)

Throughout the work of placing or removing needles or opening by escapement, the attendant is obliged to be on a narrow foot-bridge, and while there to use considerable exertion above a rapid current, no matter what the weather, and as often at night as by day; his work is certainly very dangerous.

Careful watching is necessary, at least at certain times and for certain rivers, for the least negligence may cause the submersion of the dam, and result in serious damage.

As soon as the work of removing the needles of a dam is begun, the current sets toward the bays that are wholly or partly open; its strength increases with the number of needles removed, and if the pass is near the lock, boats may miss the entrance and be drawn against the trestles.

The removal of the needles, even if only partial, ends, at last, even when the open-

ings are wide, in causing scour below the pass. This scour is much more surely produced if the dam is turned into a spur-dike, as is the case when a number of bays are entirely opened, either by escapement or by successive removal.

When a trestle is laid down, the attendant determines by means of a mark on its connecting-chain if it is well on the bottom. This verification can be done with sufficient accuracy when the depth of water is not great; but if the depth exceeds 6½ feet, it becomes very difficult, and is often deceptive.

The trestles, even if they are perfectly lowered, remain entirely uncovered; they and their chains may be struck by a boat dragging on the bottom or by a log badly fastened under a raft, and they are still more exposed to these injuries if they are badly bedded. Moreover, it is very difficult to be sure that the trestles and their chains do not project slightly.

To sum up, needle-dams are liable to the following objections:

1. Difficulty in placing and removing needles when the trestles are higher than 8 feet.
 2. Danger to the men obliged to work on the foot-bridge, which increases with the weight of needles and the difference of level.
 3. Scour at the foot of the pass; that is, at the foot of a delicate and costly work, and which is to be dreaded in proportion to the amount of fall.
 4. Currents near the head of the lock, or near the channels for navigation, where there is but one pass.
 5. Continual watchfulness at certain times, and danger of submersion.
 6. Difficulty of accurately bedding the trestles when they are high.
 7. Unhealthfulness produced by the stoppage of floating bodies.
- If a long, permanent weir is connected with the dam the danger of submersion or of scour diminishes, but the cost is great.

MOVABLE DAMS ON THE UPPER SEINE.

The first step towards the present Chanoine wickets was the Thénard system of double shutters. This worked very well for small lifts, but was unmanageable when the lifts were increased. An effort was made to get additional working-power by establishing above the shutters a service trestle-bridge and by using a traveling windlass; but this did not entirely remedy the difficulty, as the system of hinging was such that enormous power was always required to raise the last shutters. This defect in the position of the hinge caused M. Chanoine to try the effect of putting it near the middle, and of supporting the axis by a horse, that was itself movable around its sill. As these wickets have already been fully described, it will not be necessary to repeat the description.

M. De Legrené sums up the advantages of the Chanoine wickets as follows:

1. Possibility of increasing the heights of dams.
2. Safety and ease of maneuvering.
3. Automatic regulation of the level of the pool.
4. Removal of the force of the current from the vicinity of the head of the lock, and of the channel.
5. Scour only to be guarded against below the weir.
6. Repairs easily made and seldom necessary.
7. Absence of obstacles to the passage of floods.
8. Facilities afforded to the method of navigating by means of artificial waves.

The details of the system constructed on the Upper Seine and Yonne will be given further on in an extract from the latest reports on these dams.

MOVABLE DAMS ON THE MARNE.

The number of locks and dams built for the improvement of the navigation of the Marne, between Epernay and Meaux, is twelve, but the description which we are about to give only applies to the eight built in 1863, 1864, and 1865, which are named as follows: Mont-Saint-Père, Azy, Charly, Méry, Courtaron, Saint Jean, Iles-les-Meldeuses and Basses-Fermes; this last being situated a short distance above Meaux.

Of the four others, two are needle-dams, and the other two, (Damery and Courcelles) which have wickets, and were built in 1853 and 1862, differ a little from the last eight.

Each dam on the Marne overcomes a fall of nearly 7 feet, and consists of—[Fig. 49]
 1. A submersible lock 25½ feet in width and 167 in length, between miter-sills, which is placed on the bank used for towing.

2. Navigable pass with swinging wickets, [Chanoine.]

3. A weir provided with drum-wickets, [Desfontaines.]

4. A pier, an abutment, and other accessory works with which we have no concern at present.

Each navigable pass has 82 feet of opening, and is provided with 20 wickets, like those used for the navigable passes of the Upper Seine. Each wicket has a width of four feet, and a height which varies according to the dam, from 8 feet 8 inches (Iles-Meldenses) to 10 feet 2 inches, (Mont-Saint-Père.) The sill of each pass, placed at first at 2 feet below low-water, has been raised to 21 inches below low-water, by placing a cover 3 inches thick upon the original sill, with the view of better protecting the wickets when they are laid down. The space between two adjacent wickets is 2 inches; when the wickets are up, their tops are 2 inches below the normal level of the pool; consequently they permit an overflow 2 inches deep when the pool is at this level.

On the up-stream side of the 20 wickets of each pass are placed 20 trestles, from 8 feet to 8 feet 10 inches high, which work is a recess in the floor. These trestles have a triple object, that is:

1. To support a first service-bridge, raised from 5 feet 6 inches to 6 feet 4 inches above low-water, and upon which rolls a windlass for raising the wickets.

2. To receive after the closing of the pass an increase of height from 2 feet 7 inches to 3 feet 4 inches, so that the floor is thus raised 20 inches above the pool, and forms a communication between the lock and the pier.

3. To serve in case of need as a support for needles, and to form a Poirée dam. The dividing the trestles into two parts, one placed on the other, is doubly advantageous; in the first place the trestles are shorter, and in consequence the necessary interval between the last trestle and the pier is less, as also the recess to be made in the latter to receive the top of the trestle, and finally the first service-bridge can be nearer the water-surface, so that the chains of the wickets can be pulled under an angle more favorable for lifting them.

Each weir is 162 feet long, and is composed of a fixed and a movable part; the fixed part consists of a mass of beton faced with masonry, poured between two lines of piles and sheet-piles, with 25½ feet interval between the lines. This mass rises to 3 feet 5 inches below the level of the pool; or, which is the same thing, to an average height of 3 feet 11 inches above low-water. This fixed part is surmounted by 33 movable wickets, 4 feet 11 inches wide, with their tops, when they are up, at 3 feet 3 inches above the permanent portion; that is to say, at 2 inches below the level of the normal pool. These wickets, designed by M. Desfontaines, and which we have designated as drum-wickets, (*hausse à tambour*), are still very little known; they therefore require a detailed description, the elements of which are found in the explanation attached by the inventor to the model sent to the London Exposition in 1862. These wickets are shown in Figs. 46, 47, 48, 50, and 51.

The object of M. Desfontaines was to utilize the power caused by the fall at each dam in such a manner that, in order to maneuver by means of it, the attendant would only have to direct its action in a simple and an easy way. The solution appears to us as complete as it is ingenious. The following is quoted from the above-mentioned notice:

"The moving apparatus consists of a series of gates, independent of each other, and turning around a horizontal hinge placed in the middle. The upper half is the *wicket*, properly so called. It is this which makes the pool. The lower half, which we will call the *counter-wicket*, has no other function than to carry along the wicket in the movement impressed on itself. It is inclosed in a quarter of a horizontal masonry cylinder, of the same length, whose axis coincides with the hinge, and in which it can consequently make a quarter of a revolution. The horizontal limiting surfaces of this quarter of a cylinder, or, if it be preferred, of this drum, do not pass exactly through its axis. One of them, the horizontal one, is slightly raised parallel to itself, and the other, the vertical one, has been similarly moved back, so that they leave empty spaces between them and the counter-wicket when it is in its extreme positions. The latter has also been slightly bent downward, in order to diminish the raising of the horizontal bounding surface, and thus prevent it from masking a part of the wicket. Finally, the ends of the drum are closed by two sheet-iron partitions, in which two rectangular openings have been made, corresponding to the empty spaces which have just been mentioned."

The successive drums, thus provided with their wickets and counter-wickets, are made in the body of the weir. They rest upon the béton contained in the inclosures, and are in close contact with each other.

"If we now consider the whole body of drums, we see that by their union they form below the crest of the weir and along its whole length a single tube, resting at one

of its ends against the face of the pier, and at the other against the face of the abutment, and divided by the counter-wickets into two longitudinal compartments.

"In the pier itself, just above and below the line of the drums, two vertical wells are made, which communicate by culverts, one with the upper pool and the other with the lower pool, and these two wells also communicate with each other by means of two horizontal cast-iron pipes built into the masonry, and closed at each end by valves. These pipes fork in front of the openings made in the sides of the drums, and, passing through the pier, connect with these openings in such a manner that one connects with the up-stream compartment and the other with the down-stream one.

"This settled, if we suppose the four valves in the pier closed, all the wickets laid down on the floor of the weir, and consequently all the counter-wickets horizontal, and if we then open the up-stream valve of the pipe corresponding to the up-stream compartments of the drums, the water of the upper pool will immediately fill this compartment, and will then press on the counter-wickets with a force corresponding to its height above them, pushing them before it until their course is arrested by hearters, which are so placed in the drums as to stop the counter-wickets at the moment when the wickets, carried along in the movement, assume a vertical position.

"If now the up-stream valve of the pipe which has been opened be closed, and the down-stream valve which had been closed be opened, the water which had entered the drum will escape into the lower pool; the counter-wickets, relieved from pressure, will no longer be able to hold the wickets in a vertical position, and the latter, yielding to the pressure against them, will lie down on the weir.

"The maneuvers of raising and lowering the wickets are thus reduced to the simple opening and closing of two valves; moreover, as the rapidity with which the wickets move depends upon the speed with which the compartments of the drums are filled or emptied, it is easily conceivable that we may, if we so desire, so regulate it that the operation will be performed gently, without vibration and without shock. This condition is essential in order to preserve the mechanism.

"When the wickets are up, there will necessarily be more or less leakage around the edges of the counter-wickets. If this is left to accumulate in the lower compartments, they would soon be filled and the pressure on the counter-wickets would be neutralized, and the wickets would fall; but, to avoid this inconvenience, all that is necessary is to open the down-stream valve of the second pipe in the pier, which communicates with these compartments, and the leakage will flow off into the lower pool as fast as it occurs. Strictly, it would suffice to make this water pass to the ends of the compartments; but by carrying it on to the upper well, we obtain the power of acting with very great force on the wickets, that are slow to fall when the weir is to be opened; it is only necessary to close its down-stream valve and to open its up-stream one to cause the water of the upper pool to enter the lower compartment, and, by pressing the counter-wickets in reverse, to add its pressure to that which is directly on the wickets.

"Dams that permit overflow have the immense advantage of seldom requiring maneuvering, as generally they only need be lowered in heavy floods, when an overflow of the banks is threatened. However, this is not always the case, as the lowness of the banks, the neighborhood of a manufactory, or of a low bridge, &c., may cause even small fluctuations in the level of the pool to be injurious, and may make it necessary to open for rises of from one to two feet. But then a serious inconvenience presents itself, for the throwing down of the wickets along the whole length of a weir will unmask an opening greater than is necessary for the passage of a rise, and the upper pool will fall in a few minutes below its normal level. To meet these special cases, the movable apparatus has received a slight modification, of which we will now speak."

Each wicket has a prop hinged to it in rear, whose foot moves in a cast-iron slide fastened to the floor of the weir. This slide has no hearter, and is merely used as a guide. A horizontal iron bar in a suitable channel extends parallel to the wickets for the full length of the weir. This bar has a raised side, in which suitably-arranged notches are cut. If we desire to lower all the wickets, the bar is moved so that a notch comes opposite the foot of each prop, and there is then nothing to prevent the wickets from falling. If we think it desirable to partly lower some of the wickets, the bar is moved so that the raised side closes the slide of these wickets only. When the feet of the props reach this movable hearter, the movement of the wickets is stopped. As the bar is only worked when the wickets are up, there is no pressure against it, and no difficulty in setting it as may be desired. It is placed at such a distance from the wickets that when they are stopped by it they stand at half height.

Besides pipes in the pier, a similar arrangement is made in the abutment, for which the following reasons are assigned :

"In the first place, by this arrangement twice as much water can be passed into the upper compartments of the drums, and to that extent the raising and lowering of the wickets is more speedy and certain.

"Consequently the power is obtained of causing strong currents in the drums, which sweep out the sands that are deposited there. In fact, experience teaches that by the simple movement of the valves it is practicable to drop a greater or less number of wickets, and we can drop almost any desired number. In fact, it can easily be understood that if, while the wickets are up, the down-stream valve of the raising-pipe (the one corresponding to the upper compartments of the drums) be opened and the up-stream valve be closed while the opposite arrangement is made in the abutment, a current will be started in this compartment whose pressure, quite strong near the abutment, will decrease toward the pier, and near the latter will be insufficient to hold the wickets vertical. Two or three wickets will then fall. If, in this state of things, the down-stream valve of the lowering-pipe (the one corresponding to the lower compartment of the drums) be closed, and the up-stream valve be opened, a current will be established in this compartment whose counter-pressure, strong near the pier, will decrease near the abutment, and some more wickets will fall. Between these pressures and counter-pressures, or, if it is preferred, between these two opposite forces, which act at once upon all the wickets with variable intensities and in opposite directions, one of which predominates at one end of the weir, and the other at the other, there will necessarily be found along the weir a passing point where these two forces will be in equilibrium. On one side of this point all the wickets will fall ; on the other side they will stay up ; but as the intensity of each one of these two forces depends upon the greater or less opening of the pipes, it is possible, by suitably working the latter, to bring near or to move away the passing point, and, consequently, after a few trials, to drop any desired number of wickets."

The method of working the valves is simplified by placing the two pipes vertically over each other, and having but one valve for the upper end of each, and one for the lower end. In practice it is found that when one end of a pipe is open the same end of the other pipe is closed. Each valve is therefore arranged so as to close one pipe as it opens the other. Moreover, as the two ends of the same pipe are never both open or both shut at the same time, it is advantageous to connect the two valves by a balance-beam so that they may always work together. This arrangement is shown in Figs. 46, 47, 48, and 50.

The whole combination could be made automatic by connecting the rod of the upper valve with a float, but this has not yet been done, as the desirability of making dams automatic is yet doubtful.

The following is the method of working such a dam as has just been described :

If the dam be supposed closed, and the discharge near that of low water, it will be necessary to close the spaces between the wickets by needles in order to keep over the whole dam an overflow two inches deep, which secures the normal level of the pool. If a storm occurs, or a slight increase of discharge, these joint covers are removed ; if the volume discharged continues to increase, and the overflow deepens, it can generally be permitted to do so without inconvenience, and without the need of maneuvering, until the depth is from 12 to 20 inches, the wickets of the pass being so centered as not to swing spontaneously under this depth of water. When the overflow attains a depth that ought not to be exceeded on account of the lowness of the banks, or the existence of bridges and mills above, the weir-wickets are partly lowered by making use of the notched bar ; that is, the tops of the wickets are lowered about 20 inches, either throughout the whole length of the weir, or only for a certain distance, care being taken at the same time to properly proportion the opening of the valves ; if this lowering of 20 inches does not suffice to pass the rise, it is first necessary to raise all the wickets, then to move the notched bar so as to leave the slides clear, and finally to open the weir for its full length. When the rise is past and the pool falls below its normal level, the weir-wickets are half raised by the aid of the notched bar ; then, as the discharge diminishes, some of the half-raised wickets are wholly raised, until finally the whole weir is again closed.

When the high-water season arrives, all the weir-wickets are dropped, and the tringles of the navigable pass are laid down ; the pass is then opened by dropping the wickets by means of the tripping-rod.

When the season returns, when the river no longer affords a natural depth of $5\frac{1}{2}$ feet, arrangements are made to raise the dam. To do this the trestles of the pass are first set up, and the low bridge, which carries the raising windlass, is constructed. Each trestle is supplied with a chain which is fastened to the breech of the opposite wicket; this chain is pulled by the windlass and the wicket is raised; when it ceases to ascend, that is, when the prop is in its place against its heurter, the wicket is left on the swing, and the others are raised in the same manner. When all the wickets of the pass are thus on the swing, they are righted in succession by bearing down on the breech, or by pulling on the chase with a boat-hook. When the discharge of the river is small, and there is, therefore, no fear of making too great a fall while the pass is being closed, which might make it difficult to raise the last wickets, it is unnecessary to first swing the wickets, and each one is righted as soon as its prop is in place above its heurter.

Experience has shown that the last wickets can easily be raised even when there is a fall of $3\frac{1}{2}$ feet water.

When the navigable pass is closed, the extension bents are placed on top of the trestles, and on them is constructed the service-bridge, which, as has already been stated, is 20 inches above the normal pool; lastly, the valves of the weir-pipes are worked in such a way as to raise the wickets.

It can be seen from the above that with the drum-wickets it is necessary to have the crest of the permanent weir about half-way between low-water mark and the surface of the pool, in order to provide space for the counter-wickets without going below low-water, as this would be costly, and make their maintenance more difficult. It is also essential that the permanent part of the weir should produce a head of water in order to obtain the power needed to raise the wickets.

The lifts of the eight dams on the Marne vary from 6 feet 7 inches to 3 feet 2 inches above low water, and their average lift is 7 feet 3 inches.

Raising the pass-wickets by means of a boat is not practicable on the Marne, as the greater height of the weir makes it necessary to first raise all of the pass-wickets on the swing, which method deprives the boat of any points of support, and makes the use of a service-bridge imperative. This bridge is also useful to secure communication with the pier, in which are the pipes for raising the wickets of the weir, and it also serves for the construction of a needle-dam in case of necessity.

Comparing the system adopted on the Marne with that used on the Upper Seine, M. De Lagrené comes to the following conclusion:

1. The Marne system is well adapted to high dams, but not so much so as the Seine system, (Chanoine wickets,) as it requires a greater height of weir.

2. On the Marne there is danger to the attendant in having to cross to the pier on the narrow service-bridge ($2\frac{1}{2}$ feet wide) at all hours and in all weathers, and it increases with the length of the bridge. A hand-rail or rope can, however, be used to diminish this danger.

3. The Marne system does not regulate automatically the level of the pool, but it is thought that the level will be sufficiently regulated by the overflow, if the wickets be hinged at a suitable height.

4. It has the same advantage as the Seine system in having the weir placed on the side farthest from the lock.

5. The Marne weirs have the great advantage of permitting the use of the notched bar for lowering the whole movable part of the weir to half height, by which arrangement we can avoid the concentrated currents that, on the Seine, rush through the openings left by such wickets as have swung of their own accord. These concentrated currents cause dangerous scours below the weir.

6. The Marne weirs can readily be repaired, as all the movable parts are above low water.

7. The Seine system offers less obstacle to the passage of floods.

8. It is also better adapted to navigation by temporary artificial floods.

9. Nearly twice as much masonry is used in the Marne weirs as in those built on the Seine, although it is thought that much of this excess might be avoided.

COMPARISON OF POIRÉE, CHANOINE, AND DESFONTAINES SYSTEMS.

In Vol. XV, 1868, *Annales des ponts et chaussées*, M. Saint-Yves, engineer *des ponts et chaussées*, discusses the subject of movable dams, and replies to the article just quoted of M. De Lagrené.

The following is the substance of his remarks :

In reference to Poirée needle-dams, he states that, at the Marlot Dam, the trestles have a height of 11 feet. The first needle-dams were accompanied by permanent weirs, raised to the level of the upper pool, and the trestles were made higher than this level, so that the surface of the pool was regulated by the weir only. As the lift of dams was increased it became impossible to use such high weirs, and at some dams they were altogether omitted, the regulation of the pool being accomplished by suitably spacing the needles.

M. Saint-Yves denies that there is any excessive labor required of the dam-tenders, for they are not picked men, and they find no difficulty in carrying along the bridge two needles at a time, each weighing from 26 to 33 pounds. He also states that the placing of the needles is neither difficult nor dangerous ; that a needle seldom misses the sill, which presents a shoulder of 6 inches ; and that, when it does miss, the attendant has only to lower his hand to prevent being carried overboard. The needles are always removed by hand, even when the lift reaches 10 feet. The work requires skill, but it can easily be acquired in about two weeks. The width of the foot-bridge has been increased to 3 feet, and each plank is now kept in place by three claws, which hold them perfectly steady. Maneuvers executed from a bridge are much less dangerous than those from a boat. Moreover, except in rare cases, night-work on the Lower Seine is not required. The exceptions are limited to the cases of a discharge of the pool above, and to the effect of the tides. Inconvenience on the first account is prevented by the service regulations, as no important maneuver is permitted without notice to the dam-tenders above and below. The tides only give trouble at Martoe, and this has been obviated by the addition of a weir, provided with automatic Chanoine wickets.

The partial opening of a needle dam has never prevented a boat from entering a lock. The dams are generally placed at the lower end of the lock, and only occasionally at the middle. As the openings in a needle-dam extend to the bottom, and are evenly distributed either in one bay or in a number, and as there is never a flow over the top of such a dam, there is evidently less danger of scour below this dam than below any other. Moreover, scour is chiefly to be dreaded in times of high-water, when all dams are out of the way.

The highest trestles can easily be raised by two men with a boat-hook, and the use of chains has been abandoned, thus removing the only thing that prevented the trestles from lying flat in the recess ; moreover the sill now projects 14 inches above the trestle recess, as do also the pavement below the recess and the piling, so that boats and rafts that clear them must clear the trestles. As to the charge of unhealthfulness due to stopping floating bodies, M. Saint-Yves very properly says that the charge might equally be made against any dam whatever ; but that the needle-dam is the least objectionable on this score of any, as the removal of a few needles will readily pass anything through it.

He makes the following comments on dams formed by Chanoine wickets:

In raising Chanoine wickets the attendants work from a boat, and therefore are much more exposed to danger than if they were on a bridge with a floor 3 feet wide. The joint-covers that must be used during low-water cover spaces of 4 inches, and they therefore must have a cross-section at least 6 inches square. They therefore can hardly be called needles, and as the pressure on them for a length of $11\frac{1}{2}$ feet is 2,020 pounds, they evidently can only be removed by means of the boat; this operation is probably safe enough at the pass, as the pass-wickets are stable, but it is very unsafe at the weir, as any pressure against the chases of the weir-wickets will swing them. The joint-covers of the weir will therefore have to be abandoned, and left to be carried off by each rise. Moreover, the effect of the joint-covers will be to make all of the weir-wickets swing at the same time; and, as this will frequently occur, the result will be that, in practice, the covers will not be replaced, and the dam will not be sufficiently tight. [It will be observed that, in the system as now employed on the Upper Seine, the weir-wickets are maneuvered from a service-bridge, and therefore the above objections no longer apply.]

M. Saint-Yves denies that floating bodies will all be drawn away from the pass to the weir, because their crests are at the same height during the greater part of the time, and there will consequently be the same flow over each, and therefore bodies will strike one as often as the other. There is also some danger that boats or rafts going through the pass, and drawing all the water, may catch on some of the Chanoine wickets, and tear them out, for they are on the same level as the sill, and are not protected like Poirée trestles. The Chanoine wickets have a multiplicity of parts, and repairs to them must be made by means of a skiff, or by employing a diver, while Poirée trestles are often replaced from the foot-bridge without any difficulty, and without using a skiff, or needing a diver.

The greatest advantage of the Chanoine system is the facility which it affords of opening gaps, so that boats may pass without going through the locks.

He thinks that, as the Desfontaines wickets require to be sunk about one and a half times as deep as the lift which they create, they can hardly be considered a system of movable dams; but, on the other hand, the results thus far obtained show that they are the best, the easiest worked, and the most reliable of all wickets designed for use on weirs. They have not yet been made automatic, although M. Desfontaines thinks that they could readily be made so by using floats. Where self-regulation is not a necessity, they appear preferable to any other combination. He does not consider the Poirée needle-dam perfect, but that it has been very successful wherever thus far used, although of late an increase of lift has been called for, and new exigencies have arisen.

The history of the construction of movable dams is as follows:

The first type of movable dam is found in the old river-gates, the elements of which consisted of two pieces placed transversely to the current, one at the bottom and one at the top; the first (the sill) stationary, the second (the boom) movable. Against these two horizontal chief members rested vertical rafters, like needles, whose feet were supported by the sill, and their tops by the boom. Lastly, boards placed horizontally completed the closing, and made it nearly water-tight. This is the river-gate, as it still exists upon a great number of streams, and we have seen many specimens of it, especially on the Eure.

This primitive construction only partly satisfied the needs for which it was established, and besides it is only practicable on very narrow streams. The opening of these gates requires long and painful labor. They are not admissible upon rivers of any

width, where the rises are at all rapid, and M. Poirée had to discuss an entirely novel question when he was seeking after his system of dams.

Every movable dam ought to form a connected body of supports, designed to sustain a curtain, which at will can be made as tight as possible, and which is placed at right angles to the current. How, then, ought the members to be arranged which hold up this curtain?

The first necessity was to suppress the upper support of the river-gate, so as to shut off by a single gate the whole width of the water-course, and to establish axes of rotation fastened to the bottom of the river.

The most natural and logical idea was evidently to profile these members in the direction of the current, and to give the same direction to the axes of rotation. Under these circumstances the lowering and raising of the members could be only moderately hindered by the action of the current.

With the opposite arrangement, that is, when the axes of rotation are established at right angles to the current, if the lowering is helped, and possibly even precipitated by the pressure of the water, the raising becomes that much more difficult, and demands maneuvers which can only be accomplished by the aid of special machinery. Thus we see that the invention of M. Chanoine is but an extension, a perfecting, of the invention of M. Thénard, which latter was only designed to be placed on top of weirs; that is, to act under circumstances where the pressure of the water is feeble and sometimes null.

Under this view the invention of M. Poirée should be considered as the most logical

The movable trestles of M. Poirée, whose part, as we have said, is to act as frames for supporting a curtain, which in reality forms the dam, are not only very logically and very rationally conceived, but, in addition, they have the immense advantage of being a natural support for the bridge, which latter may be called the working-ground for the dams. In every system whose axes of rotation are at right angles to the current, even in the ingenious system of M. Desfontaines, the possibility of making a foot-bridge out of the necessary members of the system is entirely lacking; it is necessary to employ for this purpose an independent construction.

We finally come to the part of the dam which must resist the force which is to be overcome, the maneuvering of which brings about a direct conflict with the force of the water. To obtain an easy and practical solution of this question, M. Poirée reduced his tools to the smallest possible dimensions, and from this consideration came the invention of needles. The pressure in maneuvering is in direct ratio to the surface of each one of the elements. It is, then, only in accordance with the enlightened judgment and perspicacity which characterize M. Poirée's system that the dimensions of the needles, the elements of the great curtain of the dam, were reduced as much as possible.

The other systems have been conceived on the idea of substituting for the needles elements individually very small, and consequently very numerous, a complete apparatus of shutters, which are much more complex, but are also fewer in number. The employment of axes of rotation at right angles to the current is a necessary consequence, that could not have been avoided.

The raising of the shutters, which takes place against the current, presented a very serious difficulty. It has been very skillfully overcome in the plan of M. Chanoine by the use of two parallel axes of rotation placed at different heights. This arrangement permits the wicket to be kept practically parallel to the direction of the threads of water while the support is being raised. Theoretically the water-pressure is only exerted upon the edge of the wicket and upon the members of the support. Practically this is not exactly the case, and the exertion to be made exceeds the quantity of work that could be required of two or three men unsupplied with mechanism. Special apparatus must therefore be used.

M. Desfontaines's solution, which likewise employs a system of axes turning at right angles to the current, is certainly very ingenious and very satisfactory. The method of raising M. Desfontaines' wickets is simple, and but one motion is necessary, while to lift the Chanoine wickets two operations must be performed and two motions are required. The Desfontaines wicket rises directly against the current, without the aid of any detached or outside machinery. The force utilized is not that of man, increased by mechanical intermediaries. It is the very force to be overcome that assists the engineer, and, blindly obeying the intelligent direction which is impressed on it, contends against itself, and, from the enemy which it seems to be, becomes a docile instrument.

This remarkable result is obtained by the simplest means. Undoubtedly the iron frames of M. Poirée, with their curtain of needles, offer the greatest simplicity in construction. But the system of M. Desfontaines, several examples of which may be found on the Marne, is reduced to a movement of valves, connected together by a balance-beam, which work under a simple and easy impulse, and to wickets in one piece, which turn around a horizontal axle, without the complication of counterpoise, retaining-chains, props, or tripping-rods. In view of its unity and of the simplicity of its con-

ception and its working, it is one of the most remarkable inventions that ever originated from the laborious investigations of engineers.

But, in consideration of the necessity of a carefully-constructed inclosure, this system, for the present at least, ought to be restricted to use on weirs.

Besides the considerations just mentioned, it is of the greatest importance that a dam should be susceptible of being made water-tight, should necessity demand it. In this respect he thinks that there is a great deal yet to be done. The difficulty arises from the fact that the fall at a dam reaches its maximum when the river has its minimum discharge, and that at this time the water passes through the intervals with the greatest velocity, and more may thus be wasted than can be supplied from above, thus causing a decline in the level of the pool. At the same time, owing to the absence of back-water, the pressure on the needles is greatest, and they are often broken during the maneuvers necessitated by rises.

The following are M. Saint-Yves' conclusions as to the system that should be used in various cases:

If the river in question can only be navigated by artificial waves, in which case it is necessary to pour out in a short time the whole retained body of water in order to send forward a large volume, capable of increasing the navigable depth temporarily, but very appreciably, we think that it would be better to use Chanoine wickets, which seem preferable to the needle-dams with escapements, which are used on the Yonne. The advantage to navigation appears to us to exceed the inconveniences which we have pointed out, and which result from a relative imperfection, which subsequent studies may cause to disappear.

If the river in question has a regular regimen, with a discharge sufficient to assure, by means of pools suitably spaced, the draught necessary for a good navigation, we would not hesitate to choose Poirée dams, on account of their safety and facility of handling, and the means of communication which they give from one bank to the other for the superintendents and for those who have the care and working of the dams.

In regard to weirs, a distinction must be made. Either self-regulation is indispensable, or it is only an advantage. If it is indispensable, we think that it is only so in order to secure an additional and supplementary opening to the waters which threaten to submerge the works, and not at all in order that this opening may be closed instantaneously. On this supposition the wickets of M. Chanoine are the best adapted; but we think it important to make a reservation, that is, that the swinging should not be limited to a slight lowering below the level of the pool, which makes it necessary to have an expensive and sometimes impracticable lengthening of the weir, but that the swing should be increased as much as possible by entirely taking away the power of spontaneous rising. In a word, the wickets of the wier should be considered as semi-automatic. A foot-bridge established above the wickets will permit the dam-tender to raise them mechanically. We think that in this way alone is it possible to give a sufficient discharge over a limited length of weir.

If self-regulation is not necessary, M. Desfontaines' system appears to us preferable for crowning weirs. In fact, the simplicity of the wickets, the ease with which they are worked, and the exact control of their fall, are precious qualities, by which results as powerful as they are sure can be obtained when the weir is not too long.

In conclusion, we think that the comparison between different kinds of dams should be limited to the Poirée and the Chanoine, and that the Desfontaines wickets, thus far only applicable to weirs, should be considered as auxiliaries, but not as a system.

REPLY OF M. DE LEGRENÉ.

In tome XVI, 1868, *Annales des Ponts et Chaussées*, M. de Lagrené replies to M. Saint-Yves, and the following is a brief summary of his remarks.

He begins by quoting, in reply to the latter's assertion that needle-dams are not dangerous, a statement of M. Cambuzat, who says:

With needle-dams there is really considerable danger to men who open them in rainy and frosty weather and during floods, or at night, while in working wicket-dams there is no danger at all to the attendants.

He adds:

That in 1859 a lock-tender was drowned at the Epineau Dam while opening it on the arrival of a small rise, and that very often the attendants fall into the water during the opening of needle-dams.

The danger seems to be much greater on the Yonne, where navigation is intermittent, than on the Lower Seine, where night work is never necessary. On the Belgian part of the Meuse, as on the Yonne, the attendants often fall into the river, and in 1866 two of them were drowned at the Haignaux Dam.

It seems to me that in every case where the discharge of the stream in question varies rapidly, or where there is navigation by artificial waves, the preference, if only on the score of humanity, ought not to be given to needle-dams, unless the methods of working them are changed, which is probably quite practicable.

M. Cambuzat recounts several instances of trouble with wicket-dams, such as tripping-rods and horses broken, wickets remaining up, scour at the foot of the passes.

Injuries to some of the parts appear to me to be accidents which prove nothing against the system; in fact, I can cite the Melnn Dam, whose navigable pass is furnished with fifty wickets, which were maneuvered during all the artificial floods of 1865, that is about fifty times, without a single wicket ever refusing to fall, and without any damage whatever being reported. He acknowledges, however, that the construction of a Chanoine wicket-dam demands very great care in the exact location of all the parts, and that the attendant must also be very watchful, when raising the wickets, to see that no foreign matter interposes between the heurter and the foot of the prop, otherwise the tripping-rod might not act on it.

The weir that regulates the level of a pool is the most important part of a movable dam; it ought, if possible, to give passage for an overflow of such length that its depth shall in some measure suffice for regulating the level of the pool without any intervention of the lock-tender. If, in consequence of an increase in the discharge, the overflow no longer suffices to pass a rise, the weir ought by spontaneous movement to give an increase of discharge corresponding to the supply; that is, it should increase or decrease with the latter. Finally, it is desirable that the lock-tender should be able whenever it is necessary to control these spontaneous movements, and at any instant to have perfect command over the apparatus for closing.

If a weir is so arranged as to fulfill the above requisites, it seems a matter of indifference how the object is accomplished, as where there is a continuous navigation the pass is but seldom maneuvered. The system that uses a needle-dam on the weir, and wickets in the pass, seems objectionable, as it does away with a regulating overflow where it is needed, and places it where it may be injurious.

The article concludes with a description of the Suresnes dam, with which the author is very familiar.

The navigable pass of this dam, or rather the pass adjoining the Suresnes lock, is closed by needles; the trestles, sixty-five in number, are 11 feet in height and are spaced at intervals of 3 feet 7 inches. The dam was first closed on the 2d of June, 1867, and since then the fall at this dam, which varies according to circumstances, has never exceeded 7 feet. The number of needles in use or in store on the 2d of June was nine hundred. Between the 2d of June and the 22d of October, 1867, that is less than five months, five hundred of these needles were broken. Leaving out of consideration two hundred which were broken by being struck by a boat, there still remain three hundred cases of rupture, which occurred while placing or removing the needles, and sometimes while they were under pressure, without any apparent reason. These needles were 13 feet long, with a cross-section of 3 inches by 3 inches.

While waiting for another supply of needles of northern pine, with a section of 3½ by 2½ inches, pine scantling, 9 inches wide and 2½ thick, were used in place of needles, and they are still in use, although some of them (about ten) are already broken. They were placed in very much the same way as the ordinary needles; the height at which one of them ought to rest against the supporting bar when in position was known beforehand; the scantling was then placed nearly horizontal, resting on the bar at the proper mark, and then the up-stream end was slightly lowered; the current immediately carried this end under, and righted the scantling; the head was held back in order to lessen as much as possible the shock against the sill. To withdraw a scantling, use was made of a boat with a windlass; this boat was suitably fastened to a mooring-cable stretched across the upper end of the pass; each scantling was drawn out head foremost by means of the windlass, and taken on the boat.

This method of removing the needles of the Suresnes dam is a necessity whenever the fall is as much as 6½ or 6½ feet. Information obtained

from the attendants at other dams is to the effect that needles are only put in place or removed from navigable passes when the fall is reduced to 5 or $5\frac{1}{4}$ feet.

MOVABLE DAMS ON UPPER SEINE.

In the same volume of the *Annals*, MM. Chanoine and Lagrené give an elaborate description of the twelve dams constructed on the Seine between Montereau and Paris, with full details of the methods used in constructing the foundations, and of all items of cost. This will be given at sufficient length for the purposes of the present report from the later report of M. Cambuzat, but reference is made to it for the benefit of those who may desire to go more fully into this subject. The following items are, however, quoted here, as they are not referred to by M. Cambuzat.

Careful observations on the river, before and after the construction of the dams, showed that they produced no sensible effect on the heights of floods. When they are submerged a very slight ripple on the surface is all that can indicate their presence. The works themselves were not injured, especially if the lock-gates were opened before the arrival of the flood. The only effect was a slight deposit of sediment in the locks.

The time allowed for passing a fleet of eight boats through a lock is twenty minutes, half of which is used in filling or emptying the lock, and the other half is needed for getting the boats in and out, and for closing and opening the gates. The use of a submerged chain for towing has increased this time to twenty-eight minutes. A single tow-boat can be passed through in fifteen minutes. The larger the lock the better, when navigation is habitually carried on by fleets, as there is a very great gain in being able to pass a whole fleet through in one lockage.

The average time necessary for raising such wickets as are used on the Upper Seine is two minutes and ten seconds for each wicket.

In dropping a number of wickets there is sometimes considerable difficulty in moving the last ones, on account of the pressure on the tripping-rod of those first dropped. This is remedied by passing an iron band under the caps of the axle of the wicket, so that when the wicket is down it is raised a little higher above the tripping-rod, and there is less danger of the weight of water pressing it against the rod.

As it is important that the lock-tender should have some index to show him, at all times, the number of the wicket on which the tripping-rod is acting at the moment, several have been invented, three of which are described. They are geared so as to move either with the tripping-rod or with the axle of the pinion that works it.

Should a wicket remain standing after the others have fallen, the lock-tender, after the current through the pass has somewhat lessened, approaches it from below in a skiff, and drops it by a side-blow on the prop.

If it becomes necessary to swing the weir-wickets at a time when the overflow is nearly sufficient to swing them of itself, it is unsafe to use the service-boat, unless it is fastened to a line of piles above the weir, as any pressure against the wickets, even though the boat has long fenders, might swing them.

A full discussion is given of a modification in the manner of connecting the weir-wickets with their horses, so that after these wickets swing, the level of the pool may be kept constant as the discharge increases. This change, however, seems not to have been adopted in practice, and therefore need not be considered here.

JOINVILLE DAM ON THE MARNE.

In the same volume of the *Annals* is an article by M. Malézieux, engineer of *ponts et chaussées*, on the Joinville dam, from which the following is taken. Joinville is about $11\frac{1}{2}$ miles above the fortifications of Paris, measured by the river, and about $4\frac{1}{2}$ measured by the St. Maur Canal.

A dam had been in existence on the Marne at Joinville for forty years. It was constructed in order to raise the water to a minimum depth of 5 feet in the St. Maur Canal, and at the same time to create a fall, which caused the construction of important manufactories along the banks of this canal. The necessities of navigation having been greatly changed, the first thought was to raise the old dam 2 feet, which would be enough to give $5\frac{1}{2}$ feet of draught in the river between the upper end of the St. Maur Canal and the lower end of the Chelles Canal. But the city of Paris became, in 1864, the owner of the manufactories of St. Maur; and from that time the motive power was used to pump up the Marne water, in order to supply the Vincennes lakes and the elevated parts of the capital. The city requested that the Joinville dam should be raised $3\frac{1}{2}$ feet, and offered to share in the cost. This was about the highest elevation that could be permitted without serious inconvenience, if not on account of the submersion of the banks above, at least on account of the heights of the cargoes of the charcoal-boats which pass through the tunnel of the St. Maur Canal. The proposals of the city were accepted by the state.

It was found inadvisable to rebuild the old dam, and an entirely new one was built about 1,400 feet below the old dam, so as to leave a basin of a little more than 12 acres below the mouth of the St. Maur Canal. This canal is a cut-off by which boats pass through two-thirds of a mile of canal instead of eight miles of river. As navigation goes almost entirely through the canal, there is little need of a navigable pass, and accordingly it is only 39 feet wide. The weir is 207 feet in length. The wickets are 3 feet 7 inches high, and their tops are 8 feet 2 inches above the bottom of the St. Maur Canal. The lift of the dam in low-water is 7 feet.

Experience on the upper dams of the Marne having shown that the Chanoine wickets were liable to many accidents, and the Marne not being a river subject to sudden heavy floods, and there being, on account of the special peculiarities of the situation, but seldom occasion for opening the pass of this dam, it was thought best to close the latter by a needle-dam, and to use the Desfontaines wickets on the weir.

The Desfontaines system has been in operation at the Damery dam since 1857, and at the Courcelles dam since 1861, but is still not well known, and M. Malézieux gives a description of it, from which we only extract such matter as has not been mentioned already.

The weir is contained between two rows of sheet-piling, 26 feet apart. The up-stream capping-pieces are even with the permanent sill, at 3 feet 8 inches below the level of the pool; the down-stream caps are at the level of low-water. Before the piles were driven, the area to be covered with beton was dredged. The least thickness of beton below the level of the low-water below the dam was taken at 4 feet, but this depth was occasionally exceeded.

The first thing is to construct the main body of masonry, which contains a cavity 7 feet wide, with a cross-section composed of a quadrant adjoining a rectangle, and extending from one end of the weir to the other. The two edges of the opening have cut-stone borders. When this is finished it is divided into sections, or drums, each 5 feet long, separated by large transverse diaphragms of cast iron. These plates enter the masonry to a depth of 3 inches, and each one has two openings cut through it; one is on the up-stream side near the top of the quadrant, and is wider than it is high, making a horizontal opening

the other is on the down-stream side, is higher than it is wide, and forms a vertical opening. The latter is made of such a size that a man can without much difficulty pass through it from one end of the weir to the other.

Each drum now received a large plate-iron wicket, which has near the middle a horizontal hinge. This hinge is a cast-iron tube, which contains a wrought-iron spindle from one end to the other. Its extremities rest on the two diaphragms, at the level of the upper border but nearer the lower. The wicket itself is formed of three arms, each 7 feet 11 inches long, and of two pieces of sheet-iron two-tenths of an inch in thickness.

The arms pass through the hinge, and inside of it are shaped as collars, in which the axis turns; they completely fill the annular space between the latter and the inside surface of the hinge.

The counter-wicket, starting from the hinge, is bent backward 1 foot 4 inches, and then becomes parallel to the wicket. The object of this is to prevent the counter-wicket from extending above the horizontal opening when the wicket is down. When the wicket is up the down-stream side of the counter-wicket coincides with the up-stream side of the vertical opening. It is prevented from passing this position by a wooden sill, against which its lower edge rests, by two moldings on the diaphragms that correspond in shape to the sides of the counter-wickets, and by a molding on the hinge which comes in contact with its upper edge. There is a play not exceeding one-seventh of an inch between the counter-wicket and the walls of its drum. To secure such accuracy of fitting the iron-work is planed, and the stone-work of the cylinder is covered with Portland cement, which is accurately shaped by a cutting-tool turning on the axis of the wicket. When the wicket is up the counter-wicket is in contact on all sides with the projections, and as its surfaces of contact are faced with India rubber, there is no leakage. When the counter-wicket is in any other position there is a slight waste of water.

Each drum is divided by the counter-wicket into two compartments, and the top of each is covered by a sheet of plate-iron, which is fastened to the sole, to the diaphragms, and to the hinge; this combination supports the hinge itself.

The abutment, which is 9 feet 10 inches thick and 25 feet long, is pierced through the middle by a longitudinal culvert whose sections vary as follows: At each extremity are two parts, each 4 feet 3 inches in length and 3 feet 3 inches wide by 4 feet 3 inches high, into which a man can easily enter; the up-stream culvert has its sole 1 foot 3 inches above the low-water line below the dam, while the down-stream one has its sole exactly at this level. In the middle, with a length of 9 feet 10 inches, and separated from the end parts by two chimneys or wells, which establish a communication with the top of the abutment, is the essential part of the arrangement, that in which the distribution of water is effected and on which depends the maneuvering of the weir. In this central part the culvert is divided into two rectangular conduits, one above the other, and only separated by a five-eighths plate of cast iron; these conduits are each 2 feet 7 inches wide and 2 feet high. An ordinary cast-iron valve placed at the upper end shuts one of these openings while unmasking the other; there is a similar valve at the lower end. A balance-beam, to which are attached the rods of both valves, communicates to the down-stream valve the movement caused in the up-stream one, or, more accurately, the opposite movement.

In the body of masonry which separates these conduits from the outer wall of the abutment, and consequently from the first drum of the weir, two other conduits are constructed, but no longer superposed. One of them, which is placed on the up-stream side and at the higher elevation, prolongs the horizontal opening of the diaphragm until a connection is made with the upper conduit in the abutment; the other prolongs the vertical opening to a connection with the lower conduit. (See the plates.)

The method of raising and lowering the wickets has already been explained.

It is essential to the successful use of drum-wickets that there should be a fall at the dam, and this is obtained by raising the permanent part of the weir. The obstacles to raising are the current and a deficiency of fall, both of which are least in low-water and greatest in high. The friction of the arms on the axis must also be overcome. It is not likely that the axes of the wickets will get untrue, as they are short and are held by three pairs of collars. The resistance of the water in the upper compartments when the wickets are lowered prevents them from coming down with a shock.

At Joinville, when the river below the dam is at low-water mark, (zero of the water-gauges,) a fall of 4 to 6 inches is sufficient to raise the wickets. If the pass is completely shut, which forces the water to flow over the permanent part of the weir, it takes about two minutes to raise the wickets and one minute to lower them. On the 5th of March, 1868, the water-surface standing at 7 feet above the dam and at 4 feet 7 inches below it, twelve minutes were required to raise the wickets, and five to lower them. On another occasion, when the water above stood at 6 feet 7 inches, and at 5 feet below, a half hour was required to raise the wickets. This is about the limit at which the Joinville wickets will work. To extend this limit would be easy, but there would be no practical advantage in so doing, and it would be a useless increase of cost, for when the water-surface stands at a height of 4 feet 7 inches below the dam, the wickets have no service to render to navigation, and the necessities that are ordinarily served by the Saint Maur pumps are more than satisfied.

It was naturally to be expected that there might be trouble at Joinville on account of the sediment and gravel that would be deposited in the drums. Experience, however, has shown that the strong currents that can be sent through the upper and lower compartments by suitably working the valves in the pier and in the abutment are sufficient to remove such deposits entirely. Care is taken to have gratings at the heads of the culverts, in order to keep out leaves, sticks, &c., and there are special valves that can be used to cut off all communication between the culverts and the upper pool during the winter season when the water is muddiest.

One great merit of Desfontaines' wickets is that they are more nearly water-tight than any others. The interval of four-tenths of an inch between the wickets can easily be reduced to two-tenths or less.

If a boat should be driven by the current against one of the wickets, and should injure it, it can at once be replaced from the spare wickets which are always in store. Such an accident could hardly happen except when the river was tolerably high, and as the upper compartments are always in communication with the upper pool when the wickets are up, in most cases the only result will be that the counter-wicket will drive back the water that presses against it, and the wicket will gradually yield to the shock and lie down.

The drums can be laid dry for repairs whenever the water below the dam does not stand higher than 3 feet on the gauge, (which is the case during half the year,) by building little dams in the piers and in the abutment, for which recesses are left. This, however, necessitates that 3 feet 7 inches be drawn off from the pool. At Joinville this plan was considered objectionable, and instead of it a line of triangular frames, 3 feet 7 inches high and 9 feet 10 inches apart, was placed on the weir above the wickets. These frames lie down like the trestles of a Poirée dam. They are used as the supports of a temporary dam of timbers 8½ inches by 4 in section, which have claws that connect them with the uprights of the frames. They are easily placed from a skiff, and the dam is made water-tight by a covering of tarred canvas, held down by weights. After the top of the weir is exposed, a little traveling-crane, running on rails and movable from one end of the weir to the other, is

used for handling the wickets. In less than a day the covers can be taken off, the wickets can be raised and examined, and all can be replaced. No pump is used unless it is thought advisable to empty the drums.

Special precautions were taken to prevent wash below the weir of the Joinville dam, as the use of a notched bar to permit the half-lowering of wickets was, for simplification, rejected. The greatest difficulty was encountered below the pass. The following is a description of this danger, and of the means taken to meet it:

The lower end of the sole of the pass is exposed to still more dangerous corrosion, and it may chance that the whole Marne will pass through this narrow opening of only 39 feet. In fact a scour, to the depth of 13 feet below low-water, was very soon formed at a distance of 100 feet below the pass. In order to keep the ultimate scour at a suitable distance from the dam, bearing in mind the difficulty of making the necessary repairs to a covering 2 feet 4 inches below low-water, the rock-work for a distance of 50 feet was covered, not by a masonry pavement, but by a strong flooring of oak timbers, bolted carefully to the caps that connected the six rows of piles.

The trestles of the pass are 9 feet 10 inches high and the one nearest to the pier is 6 feet 7 inches distant from it, so that a space has to be made for it in the pier, and this recess is separated from the culvert by a special casting. The service-bridge is 6 feet 7 inches below the top of the pier, and the latter is reached by a short ladder and four steps in the pier itself. A supplementary bridge is provided, whose floor is 4 feet higher than that of the main bridge, but it is seldom used, as the latter answers for most purposes.

The iron-work of the wickets cost 49,844 francs, or \$9,470.

The counter-wickets of the Marne weirs are generally of the same length as the wickets, but at the Courcelles Dam the former are $4\frac{1}{2}$ inches longer, and these wickets are in consequence perceptibly more readily maneuvered than any others. The longer the counter-wickets the greater the height of the river at which the raising of the wickets becomes impracticable.

To satisfy the local wants of the Marne navigation, M. Desfontaines adopted the following rules:

1. To make the height of the permanent part of the weir equal to half the difference of level in low-water.
2. To limit the sinking of the drums below the low-water line, at the foot of the dam, to from 12 to 16 inches. But these rules were neither general nor absolute.

There are some advantages in a high weir, provided it is not too costly on account of its length; such as greater security than a movable curtain, greater ease of establishing, examining, and repairing its movable parts, and less exposure of the latter to being covered by sand or sediment.

Besides this, the height secures the initial fall, which is necessary for the maneuvering of the wickets.

M. Malézieux believes that there is no practical difficulty in the way of making deeper drums and higher wickets on the Desfontaines system.

IMPROVEMENTS ON POIRÉE NEEDLE-DAMS.

In Vol. XX, *Annales des ponts et chaussées*, 1870, M. Saint Yves takes up the subject of the improvements practicable on Poirée needle-dams. The substance of his remarks is as follows:

One of the troubles with a needle-dam, especially when high, is its lack of tightness. After a careful investigation, which is given in full in the original, he recommended that the cross-section of the needles should be a semi-regular hexagon, obtained by taking an equilateral tri-

angle with sides of $5\frac{1}{2}$ inches, and cutting off from each of its three angles smaller equilateral triangles with sides of $1\frac{1}{2}$ inches. (See Fig. 53.)

On the Seine, below Paris, the dams are 9 feet 10 inches in height, and the depth provided for navigation is 6 feet 7 inches, the crowns of the masonry of the dams being placed at a low-water line. Whenever the river surface below a dam stands at 2 feet below its top, or at 7 feet 10 inches above the masonry, the movable part is thrown down, and boats can easily cross without striking the sill. In order to prevent the boats from being entirely stopped during low-water, in case of accident to the lock, each dam has a navigation-pass closed by a needle-dam. As the needles for these passes would have to be so long and heavy that they could not be handled without great labor, it was decided by the General Council of *Ponts et Chaussées* that a movable sill should be used which could be removed whenever necessary. M. Saint Yves does not approve of this arrangement, as he thinks that in course of time the movable sill would either be destroyed, or so consolidated with the masonry that it could only be removed by tearing it to pieces.

In order to remove this difficulty, M. Marini tried, at the Bezons dam, intermediate supports for long needles, (Figs. 54, 55, 56, 57, and 58.) so that they might have three points of support instead of two. A careful examination into this question shows that for heights of $12\frac{1}{2}$ feet, where the needles rest against intermediate horizontal beams, supported against the trestles at a height of 4 feet 7 inches above the sill, they resist well; and this is also the case when the height is 13 feet and the intermediate support is at an elevation of 4 feet 10 inches. With such an arrangement movable sills are no longer necessary, but more skill is required in removing needles thus supported in order to avoid being drawn into the water. The best place for the intermediate beam is a little above the center of pressure of the water. It must be observed, however, that this additional security is only obtained while the needles are in place. They are still weak to resist the forces acting on them when they are being lifted. The best remedy for the difficulty seems to be to have a special apparatus for regulating the level of the pool, so that the needles need only be lifted when the latter ceases to suffice for the discharge, by which time the lower pool will have been raised, and the pressure on the needles will thus have been diminished.

The apparatus recommended is Chanoine wickets on the weirs, but automatic action does not seem desirable, as by dispensing with it a greater swing of the wickets may be obtained. If only a short length of weir be available, Desfontaines wickets should be used, as these can lie down flat, and thus permit a greater discharge.

DAMS ON THE MEUSE.—TRESTLES WITH ESCAPEMENTS.

The arrangements on the Meuse, to open needle-dams by escapements, differ from those on the Yonne. On the latter they were designed with a view to making artificial floods, and therefore rapidity of action was specially desired. As soon as one bay was opened all the others followed, and the movement took place so rapidly that sometimes the dam-tender could not get off the bridge in time, but was precipitated into the river.

The Belgian dams, with escapements, are constructed in accordance with an entirely different order of ideas. Each escapement is put in motion by the application of an exterior force, and the openings take place singly and one after the other. The object

which the Belgian engineers proposed to themselves was to avoid the removal of the needles by hand and one at a time; and by their system they have succeeded in making daily use of needles which square from 4 to 4½ inches. The handling of these little pine joists is limited to carrying them on the dam and placing them in the water, which are easy operations that require no manual dexterity, but only the effort necessary to lift a weight and carry it on the shoulder.

By using these heavy needles the height of dams can be increased to 13 feet without using intermediate supports.

GENERAL DESCRIPTION OF TRESTLES WITH ESCAPEMENTS, AS USED ON THE BELGIAN MEUSE.

Their general shape is about the same as that of the trestles used in France. They only differ in the upper part. The cap, which forms the smaller base of the quadrilateral, is surmounted by a rectangular frame-work, which carries the escapement apparatus and the foot-bridge. (See Figs. 59, 60, and 61.)

Of the two vertical parts of this frame, one, that on the up-stream side, is composed of a piece of wrought iron, which is welded to the trestle, and is afterward bored out so as to form a tube, in which turns a vertical iron rod, A. (Fig. 59.)

The clamp-bar, which connects one trestle with the next, is provided at one end with a collar which envelops the tube, around which the clamp-bar turns. This collar is hollowed out on the larger part of its circumference so as to admit, in all its positions, (it can only describe a quadrant,) the head of the adjoining clamp-bar, B. The collar is held, so as to prevent any vertical movement, by a ring, C, which is fastened to the tube by two screws. The head of each clamp-bar is forged in the shape of a T, and enters the cavities cut out of the collar of the adjoining clamp-bar, those cut out of the tube, and lastly those cut out of the iron rod. Finally, on the under side of each clamp-bar and near its head is a vertical projection, D, (Fig. 60,) which, after the bar is turned, strikes against the cap of the trestle proper and limits its movement of rotation.

The iron rod is prevented from moving vertically by a screw, E, (Fig. 59,) which accompanies it in its quarter of a revolution, moving in a groove cut out of the tube.

The down-stream post of the top frame is arranged so as to receive a horizontal bar for supporting the iron plate, which serves to make a foot-bridge, and to bind together the trestles by means of claws. This bar has a socket on its up-stream side, which surrounds the tube.

The iron rod works in the tube by friction, and it is turned by nippers shaped like a wrench. The escapement cannot, therefore, act spontaneously.

The dams on the Meuse are divided into two passes by a pier, which is hollowed out so as to have chambers on each side to receive the end trestles. There are no niches in the abutments, and the trestles are always dropped in the same direction.

The trestles are connected by chains, but the necessity of leaving room for the clamp-bars to turn and the needles to escape compels the division of the chains into two parts, one of which is fastened to a trestle, and the other to the flooring of the adjoining trestle. When the trestles are lowered these chains are connected, but they are separated when the bridge is up.

The trestles are bedded by giving them a slight push after raising the floor, so as to disengage the claws. They are raised by using a light portable windlass. The needles of each bay are connected by a rope which passes under the flooring, and is fastened to the down-stream post of the trestle. When it is necessary to increase the discharge, a certain number of bays are opened by turning their clamp-bars. In this case the end of the rope which holds the needles of each bay is tied to a cable which is fastened to the pier or abutment, so that the needles float to them and are picked up at leisure.

From the above the author concludes that it is quite practicable to use the Poirée system, with a regulating weir provided with Chanoine wickets up to a height of 13 feet; but the semi-regular hexagonal needles should be preferred in order to prevent excessive leakage.

The best exemplification of the present practice of foreign engineers in improving a river on a plan similar to that proposed for the Ohio is to be found in the works recently executed by the French government in the Upper Seine and Yonne.

IMPROVEMENT OF THE YONNE AND THE UPPER SEINE.

The following description is taken from the March number for 1873, of the *Annales des ponts et chaussées*. This article is so valuable in itself, and so pertinent to our present investigation, that but little of it can be omitted. Unfortunately the illustrative plates do not accompany the text, but are promised in some future number. It is believed, however, that the plates that accompany the other reports sufficiently explain this one. The author is M. Cambuzat, chief engineer *des ponts et chaussées*.

The great water route connecting Havre, Rouen, and Paris with Lyons and Marseilles, by the Seine and Yonne Rivers, the Burgundy Canal, and the rivers Saône and Rhone, (see map on plate 6,) had, until September, 1871, a very defective section; in fact, a veritable gap, 118 miles long, between Paris and Laroche, where the Burgundy Canal enters the Yonne. In fact, for eight or nine months of the year, from March to November, the descent of loaded boats was only possible, especially on the Yonne, twice a week, by the aid of artificial floods or waves from the Upper Yonne, and the draught of water available varied from 2½ feet to 3 feet 4 inches, and 3 feet 7 inches at most; so that boats from the Burgundy Canal, drawing from 3 feet 7 inches to 4 feet 7 inches, were obliged to break bulk at Laroche. As to ascending craft, they were generally empty, or only carried a few tons of merchandise. This costly, slow, and altogether insufficient navigation, was accompanied by great fatigue, by danger, and by numerous accidents. Although it was somewhat less difficult on the Seine, navigation was much hindered, and often stopped, between Montereau and Paris. Since the 1st of September, 1871, there has been a continuous navigation between Paris and Laroche, thanks to 17 movable dams constructed on the Yonne, and to 2 cut-offs and 12 movable dams constructed on the Seine. The minimum depth of water in the pools is 5 feet 3 inches, and therefore boats can move up and down with perfect safety, drawing from 4 to 5 feet. At present, while the works are yet incomplete, the greater part of the loads, especially those that come from the Nivernais Canal, do not draw over 4 feet; but when the works of the same kind (that is, 8 movable dams and one cut-off, now being built between Laroche and Auxerre, where the Nivernais Canal enters) are finished, which will be by the end of this year, (1873,) the great advantages will be happily realized which the government had in view, and which were looked for with impatience, but with confidence, by the boating, commercial, industrial, and agricultural interests.

The greatest flood ever known on the Yonne, that of January, 1802, rose 16 feet at Montereau. The low-water discharge between Auxerre and Laroche is 459 cubic feet per second, and the average slope 3½ feet per mile; between Laroche and Montereau the discharge is 600 cubic feet per second, and the slope 1 foot 10 inches per mile.

The first effort to improve the navigation of the Yonne was directed toward checking the flow of the artificial floods by movable dams, in order to prevent their too speedy absorption. On this plan, descending boats and rafts were stopped at each dam, and after all had arrived a new flood carried them to the next one. But the increasing demands of commerce for a *continuous* navigation caused the adoption of the present system. Between Laroche and Montereau (the mouth of the Yonne) there are now 17 movable dams, of which 6 belonged to the old system of navigation by temporary floods. These had each a navigable pass varying in width from 194 to 230 feet. One of these dams was replaced by a new one, but the others were retained, with some modifications. Each had a lock attached for use during low-water. Eleven new dams were constructed, all of which have locks attached, except those at the heads of cut-offs, whose locks are generally at the lower end of the cut-off. The navigation passes of these new dams are 115 feet in width, and the weir has a minimum length of 164 feet. The sill of the navigation pass is placed at 2 feet below the low-water line. The sill of the weir is placed 20 inches above the same line, and therefore is 3 feet 8 inches higher than the sill of the pass. Two cut-offs across difficult bends

shorten the river a little more than 4 miles. At the head of each cut-off is a guard-lock and at the lower end a lift-lock. At the Courlon cut-off the lift of the lower lock is 12 feet 9 inches. The bottom width of each cut-off is 52½ feet.

Wherever dredging was necessary a channel was made 100 feet wide and 5 feet deep at low water.

The works for improving the navigation between Montereau and Laroche, authorized in 1861, were nearly completed in 1868, when a continuation up the Yonne to Auxerre was ordered. These new works were commenced in 1869, and although retarded by the war with Germany, will probably be completed by the end of the present year. These new works consist of eight movable dams, (of which seven have locks,) one cut-off, dredging, bank-protection, and minor works. The dam of La Chainette, just below Auxerre, has a navigation-pass 138 feet wide, closed by a Poirée needle-dam, and a permanent weir 656 feet long, whose top is even with the surface of the pool. The sole of the navigation-pass is 20 inches below low water. The chamber of the lock attached to the dam is 27 feet wide, and has an available length of 305 feet. This dam was built under the old system of creating temporary floods. The seven new dams have navigation-passes varying in width from 98 to 115 feet, closed by Chanoine wickets, with their soles 2 feet below low water. The weirs, whose soles are 20 inches above low water, are from 82 to 131 feet in length. Six of these weirs have needle-dams on the Poirée system, and one has large Girard shutters 11½ feet wide, with a vertical height of 6½ feet.

Five principal conditions controlled the decision on the position and lift of each dam:

1. The preservation of existing dams.
2. The horizontal plane passing through the tops of the wickets of the navigation-pass (whose height fixed the lift of the dam) should be 5 feet above the lower miter-sill of the lock next above, and the same distance above the intermediate bars, excepting those which were to be dredged.
3. The height of the natural banks should be at least from 16 to 20 inches above the level of the pool, excepting that certain parts near the dams were to be raised.
4. The space under the keystones of arched bridges, and under the bottom chords of truss-bridges, should be at least 18 feet above the surface of the pools, because the greatest space required for boats is seldom over 16 feet.
5. Finally, a maximum vertical height of from 9 feet 10 inches to 10 feet 2 inches to be given to the wickets of the navigation-pass.

On account of the very small flow in low-water, the surfaces of the pools were always assumed as horizontal.

When the project for movable dams on the Yonne was approved, it was not thought that wickets could be built on the Chanoine system as high as 10 feet, but recently a sluice for navigation has been constructed on the Seine, through the Port à l'Anglais Dam, whose wickets have a vertical height of 12½ feet.

Movable dams on the Yonne.

No. of dam.	Name of work.	Height in feet above all.				Look.		Pass.		Weir.		Remarks.	
		Of pass.		Of weir.		Width in feet.	Available length in feet.	No. of—		Length in feet.	No. of—		
		Distance in miles.	Lift in feet.	Wickets.	Trestles.	Wickets.	Trestles.	Width in feet.	Wickets.	Trestles.	Length in feet.		Wickets.	Trestles.
1	Month of Nivernais Canal	0.97	3.97		7.97	27.93	305.04	138.43	36	656.00		Permanent masonry weir—Old Poirée needle-dam.	
2	La Châtelaine Dam	1.86	6.06	9.84		34.44	314.88	98.40	53	82.00	7	Girard shutters on weir.	
3	Ile Brulée Dam	3.02	6.02	9.84	6.56	34.44	314.88	98.40	53	142.00	21	Poirée needle-dam on weir.	
4	Les Dumont's Dam	4.08	6.06	9.84		34.44	314.88	98.40	53	96.43	25	Do.	
5	Les Boisseaux Dam	5.05	6.03	9.84	8.04	34.44	314.88	98.40	53	81.80	30	Do.	
6	Monéteau Dam	6.92	8.30	10.16	8.04	34.44	314.88	98.40	53	52.00	21	Do.	
	Gurgy Dam	10.03				34.44	314.88					Distance shortened 2.79 miles—3 locks.	
	Gurgy cut-off		8.30			34.44	314.88						
7	Basson Dam	10.83	7.21	9.87		34.44	314.88	115.39	97	96.60	34	Poirée needle-dam on weir.	
8	La Gravière Dam	13.05	6.49	9.84	8.04	34.44	314.88	114.90	97	131.90	35	Do.	
9	Month of Burgundy Canal	14.37											
10	Epineau Dam	15.64	3.02		7.87	27.28	593.68	194.18	57	328.00	16	Permanent masonry weir—Old Poirée needle-dam.	
	Péchoir Dam	17.95	5.01	9.74	3.98	34.44	314.88	115.13	97	73.47	27	Two weirs and foot-bridge for maneuvering.	
11	Joigny Dam	20.29	7.05	9.02	5.41			115.13	97	165.31	36	Weir with movable wicket and foot-bridge.	
12	Joigny cut-off	22.51	10.66			34.44	314.88	115.95	97	165.48	36	Distance shortened 1.59 miles.	
13	Villavallier Dam	25.25	6.36	9.84	6.23	34.44	314.88	115.99	97	165.48	36	Weir with movable wickets and foot-bridge.	
14	Armeau Dam	28.92	5.15	9.74	6.13	34.44	314.88	115.99	97	165.48	36	Do.	
15	Villeneuve Dam	31.63	5.74	9.78	6.16	34.44	314.88	115.99	97	165.48	36	Do.	
16	Etigny Dam	35.31	4.93	9.11	5.51	34.44	314.88	115.39	97	178.59	39	Do.	
17	Rosoy Dam	37.95	6.10	9.84	6.23	34.44	314.88	115.39	97	165.48	36	Do.	
	Saint Bond Dam	40.89	5.15	8.88	5.28	34.44	314.88	115.39	97	165.48	36	Do.	
18	Saint Martin Dam	43.55	6.03	9.70	6.10	34.44	314.88	115.29	97	78.23	17	Two weirs and foot-bridge for maneuvering.	
19	Villeperrot Dam	46.60	6.33	9.47	3.28	34.44	314.88	115.39	97	393.00	50	Weir with movable wickets and foot-bridge.	
20	Champdieu Dam	50.00	6.46	9.73	5.87	34.44	314.88	115.39	97	165.48	36	Do.	
21	Courlon Dam	54.39	7.41	9.05	6.13	34.44	314.88	115.39	97	206.80	45	Do.	
22	Courlon cut-off	56.96	12.73		5.44	34.44	314.88			174.66	38	Distance shortened 2.65 miles.	
23	Port Renard Dam	57.25	9.53		7.68	34.44	314.88	911.23	57	985.90	30	Permanent masonry weir—Old Poirée needle-dam.	
24	Barbey Dam	59.88	2.85	9.18		34.44	314.88	115.39	97	179.25	39	Weir with movable wickets and foot-bridge.	
25	Labrosse Dam	62.79	5.64	9.84	5.58	34.44	314.88	115.39	97	197.62	43	Do.	
26	Cannes Dam	65.97	6.75	9.75	6.23	34.44	314.88	115.39	97	174.66	38	Do.	
	Mouth of Yonne	67.28			6.17								

Movable dams on Yonne—Continued.

	Distance in miles.	
Total length via cut-offs.....	67.28	The elevation of low-water mark at Auxerre above tide is..... 316.85 feet.
Add length cut-off	7.03	The total fall from Auxerre to Montereau is... 165.84 feet.
		The length of canalized river from Auxerre to Laroche is..... 14.38 miles.
Total length of river in its natural state.....	74.31	The length of canalized river from Loroche to Montereau is..... 52.90 miles.
		67.28

From the table we see—

1. That, in the first section, Auxerre to Laroche, the 8 dams have lifts varying from 4 to 8 feet, and an average lift of $6\frac{1}{2}$ feet. The two locks of the Gurgy cut-off have each a lift of 8 feet. The 9 pools between the mouth of the Nivernais Canal and the La Gravière Dam have lengths varying from four-fifths of a mile to four miles, with an average length of one mile and a half.

2. That the Epineau pool is common to the first and second sections, and has a length of two and one-half miles.

3. That, in the second section, from Laroche to Montereau, the 17 dams have lifts varying from 2 feet 10 inches to 7 feet 5 inches, and a mean lift of $5\frac{1}{2}$ feet. The two cut-off locks have lifts of 10 feet 8 inches and 12 feet 9 inches. The 16 pools between the Epineau and the Cannes Dams have lengths varying from seven-eighths of a mile to six and one-third miles, and an average length of three miles.

4. That the distance of two miles between the Cannes Dam and the Montereau bridge is a part of the first pool of the Seine, which ends at the Varennes Dam.

The width of the floor of the navigation-passes of the new dams, with wickets, is from 23 to 33 feet, measured in the direction of the current. The thickness is at least equal to the lift of the dam, and seldom less than $6\frac{1}{2}$ feet.

Between Auxerre and Joigny the body of the floor rests directly on solid rock or chalk; the masonry was laid dry in coffer-dams. Between Joigny and Montereau the main body is composed of a bed of beton, poured into an inclosure of piles and plank. On this the floor of the sole, consisting of cut and hammered stone, was placed after the water was removed.

In the masonry floor anchors, iron rods, and cast-iron anchoring-plates are imbedded, in order to bind solidly to the masonry the wooden sill against which the breeches of the wickets rest.

The floor of the weir of the new dams has generally a width of 13 feet and minimum thickness of $6\frac{1}{2}$ feet. It is entirely of masonry, or formed by a wooden box filled with beton and covered by a pavement of heavy stone.

The weir lies between a masonry pier 10 feet thick and 20 feet long, which separates it from the pass, and a masonry abutment, which is connected with the bank by two wing-walls.

Below most of the dams there is an apron, formed of heavy riprap of natural or artificial stone. At some of the dams this riprap is held in place by piles driven in quincunx order.

The passes of the twenty-two new dams on the Yonne are closed by movable wooden Chanoine thickets, 4 feet wide, with 2-inch intervals. During the season of low-water these intervals are covered by planks to make the dam tighter.

It is well known that each wicket is movable around an axis forming the cap of the horse, which itself turns around its sill, whose journals are held in two boxes fastened in the lower face of the sill of the pass. The wicket, when upright, is inclined at an angle of 15° from the vertical, and laps 3 inches against the upper face of the sill. The top is even with the surface of the pool. The axis of rotation of the wicket is so placed that the height of the breach above the sill is $5\frac{1}{2}$ of the total height, and consequently that of the chase is $\frac{7}{12}$. The cap of the horse passes through an eye in the head of a prop, whose foot is supported, when the wicket is up, against a cast iron heurter fastened in the sole of the pass. When the wicket is down the prop is retained in a slide, of which the heurter is the head. When it is desired to lower a wicket, the foot of the prop is tripped by a corresponding projection on the tripping-rod, which is moved horizontally on the sole by means of a wheel and gearing placed in the pier or in a wall of the lock, for each pass is managed by two tripping-rods, each of which acts upon one-half of the wickets, beginning at the middle of the pass.

On the other hand, the wickets, when down, are raised by a boat-hook, worked from a boat furnished with windlass and other appliances.

It is quite evident that the trestles, the props, and the tripping-rods are of wrought iron; the slides and the heurters of cast iron.

The weirs of the fifteen new dams between Laroche and Auxerre have been, since their construction, supplied with automatic wickets, with movable counterpoises, on the Chanoine plan. These wooden wickets are $4\frac{1}{2}$ feet wide, with 2-inch spaces between. The weir can be made tighter by applying joint-covers over the open spaces between the wickets.

Each weir-wicket is movable, like a pass-wicket, around a horse, which carries a prop; and for each wicket there is a heurter and slide. M. Chanoine had even added tripping-rods, which, however, he did not regard as very necessary. The axis of rotation of a weir-wicket being only 2 inches above the one-third the height of the wicket, it was only necessary that the water in the pool should rise from 4 to 6 inches above the top of the wicket to make it swing; the movable counter-weight placed at the foot of the breech, which kept the wicket up when the pool was at its ordinary level, slipped to the chase when the wicket swung. If the level of the pool fell a certain distance the wicket would swing back, and the counter-weight would fall back to the foot of the breech.

This ingenious system was striking in its simplicity, and was accepted at once after the isolated experiments made at a single dam, while specially pre-occupied in devising means for rapidly passing a flood, without exhausting the pool above or injuring the passage of river-craft; but a great disappointment was experienced when the continuous navigation on the Yonne and Seine, between Paris and Laroche, came to be tested. An official order of May 4, 1868, in approving the provisional regulations for the new method of navigation, authorized the engineers to put in operation the dams built on the Seine and the Yonne, between Paris and Laroche. The official order recommended that this delicate work should be undertaken with all the precautions necessary to prevent injury to navigation. The dams on the Seine were raised between the 18th of May and the 7th of June. The first four dams on the Yonne were closed between the 8th and 10th of June, but the raising of the thirteen others was only finished by the 5th of September, after the closing of the canals. A difficulty immediately arose on account of the co-existence of the artificial floods of the Upper Yonne, whose waves came twice a week, and swung a certain number of weir-wickets, which wickets, although called automatic, would not raise themselves until there was a fall of $3\frac{1}{2}$ feet in the pool above, from which circumstance navigation was much hindered. Thanks to the zeal and activity of the engineers, to the careful watch of the conductors, and to the devotion of the lock and dam tenders, it was possible to master the situation during low-water. With boats and different expedients devised by those in charge of the navigation success was obtained in raising the wickets with sufficient rapidity, and the improvement of the new system was finally apparent and conceded by all. But in the month of August the waters discharged from the canals, and those from violent storms, increased by the artificial flood-wave, produced disturbances in the pools that extended to Paris. In consequence of this experience, care was taken to empty several of the upper pools before the arrival of the artificial flood-wave. On the 22d of October a little rise of 8 inches from the Armançon River arrived at Laroche without being announced, and consequently without the precautions prescribed for an artificial flood-wave having been taken below. A complete derangement resulted at all the weirs and in all the pools from Laroche to Paris. Immediately the engineers proposed to establish above each weir, with movable wickets, a foot-bridge, which, with the aid of a windlass and chains, would permit the management of the wickets and the regulation of the level of the pool above; meanwhile all the dams were opened, and the system of artificial flood-waves was continued freely as formerly. A board of three inspector-generals of Ponts et Chaussées, charged with an examination, heard those interested at Joigny, at Sens, at Montereau, and at Paris. They adopted the propositions of the engineers, which, as advised by the General Council of Ponts et Chaussées, were approved by an official order of December 28, 1869.

In consequence, during the two seasons of 1869 and 1870 foot-bridges for maneuvering were built above each weir with so-called automatic wickets; and but for the unhappy events at the close of 1870, continuous navigation would have been established between Paris and Laroche by the month of September, 1870; which, however, could not be until the 1st of September, 1871, a year later. Each bridge for maneuvering is composed of wrought-iron trestles, like the trestles of Poirée dams, movable around a horizontal axis at right angles to the axis of the weir. Each trestle is opposite the middle of a wicket. These trestles are connected at their caps by two clamp-bars, which fix the width of the bridge. Between these bars is a wooden flooring, which is raised 20 inches above the level of the pool. The two clamp-bars are the rails upon which rolls the truck that carries the hoisting-windlass. Finally, to this windlass reach two chains, one attached to the head of the chase, and the other to the foot of the breech of each wicket. By the help of the windlass, solidly fastened to one or two

trestles and the two chains, every maneuver necessary to regulate the level of the pool—raising, lowering, or swinging the wickets—can be performed without fatigue and without danger. In times of flood the trestles of the foot-bridge fall into a recess nearly on a level with the crown of the weir. The planks, the clamp-bars, and the windlass are put in store. The counter-weights have been removed from the weir-wickets as no longer required.

This system has succeeded perfectly. At night each lock-tender is warned of the change in the water-surface above his dam by an alarm, put in motion by a float. Soon all the dams will be connected by telegraph, and the system thus completed will prevent surprises.

In consequence of the experience obtained in 1868 on the working of the twenty-nine movable dams between Laroche and Paris, it was decided to improve the navigation of the Yonne between Laroche and Auxerre, with passes opened and closed by movable wickets and weirs provided with foot-bridges and needle-dams. An exception in the arrangement of the weir was made at the Ile-Brulée Dam, near Auxerre—

Which was provided with large shutters, 11½ feet wide, the invention of M. Girard. These shutters, movable around a horizontal axis at the foot, placed on the upper crest of the weir, were supported by props, which were the piston-rods of the same number of inclined pumps, firmly fastened to the floor. These pistons are put in motion by the water which comes by pipes under water, communicating with a reservoir supplied by a turbine, which is itself put in motion by the fall at the dam. Finally the dam of La Chainette, at Auxerre, at the head of river-navigation, has a stationary weir, and a pass only closed by a needle-dam.

To sum up. Of the 25 movable dams established on the Yonne between Auxerre and Montereau three are on the Poirée system proper; there remains but one on the Chanoine system proper; 22 have passes with Chanoine wickets, but the weirs have different systems; 15 weirs have movable wickets with foot-bridges for maneuvering, 6 have needle-dams on the Poirée system, and 1 only has large Girard shutters. At present the working of all these dams is easily managed, without danger to the attendant, and surprises are no longer to be dreaded, thanks to the floats with alarms at each dam, and the telegraphic communication from dam to dam.

There are 26 locks between Auxerre and Montereau, while there are only 25 movable dams, because the Gurgy cut-off, just above the dam of the same name, has 2 locks. Of these 26 locks 23 are new, and their chambers have a width of 34½ feet, and an available length [between chord of lift-wall and recess of lower gate] of 315 feet, so as to receive six canal-boats coupled two by two, and two rafts coupled together; 2 of the 3 old locks, those of Epineau and Port Renard, have chambers 27 feet wide, with an available length of 594 feet; they therefore can receive six canal-boats and two rafts one after the other; a single lock that at La Chainette, has a chamber 27 feet wide, with an available length of 304 feet. This lock receives three canal-boats or one raft; which is not inconvenient, for reasons given before.

The three locks of La Chainette, Epineau, and Port Renard have the faces of their walls of cut and hammered stone; the river-wall has a thickness of 8 feet 2 inches.

Thirteen of the 15 new locks below Laroche have only their extremities and the gate recesses in masonry with vertical faces; the rest of the chamber is bounded by two paved masonry slopes with 45° inclination. [These slopes were originally made of dry stone resting upon beton, but several accidents and slides caused the dry stone to be replaced by masonry, both here and for the upper surfaces of dikes.] This rock-work, of scabble-stone for 10 locks and rough for 3, rests on a mass of beton or masonry, founded on solid rock or sustained by a line of piles and sheeting; the dike which forms the river-wall of locks in the river has a thickness of 10 feet at the top, with an exterior slope of rubble on an inclination of three base to two perpendicular; the foot of the exterior slope is protected by a line of piles and sheeting, or by heavy stones, when it does not rest on rock. The top surface of the dike is covered with masonry. This dike, which is of earth, and contains a core 6½ feet thick of puddled clay, is generally water-tight. The 2 locks of Péchoir and St. Martin have on the land side of their chambers a slope of 45°, and on the river side a vertical wall of masonry 8 feet thick, with an enlargement opposite the lower gate to contain the chamber in which are placed the wheels and pinions which work the tripping-rod of the press.

Of the 8 new locks between Auxerre and Laroche, two, those at Monctean and Basson, are on the same plan as those at Péchoir and St. Martin. The 6 other locks have their chambers bounded by two vertical masonry walls, and for the 4 locks in the river, the river walls are 8 feet thick.

The cost of the forgoing works was as follows :

	Francs.	Dollars.
The reservoir des Settons	1, 327, 680	152, 259
Seven locks and dams, between Auxerre and Laroche, at 317,000 francs, (\$60,230)	2, 219, 000	421, 610
One dam without lock between Auxerre and Laroche	140, 000	26, 600
Eight locks and dams, between Laroche and Sens, at 462,000 francs, (\$87,780)	3, 696, 000	702, 240
One dam without lock between Laroche and Sens	170, 000	32, 300
Seven locks and dams between Sens and Montereau, at 561,000 francs, (\$106,590)	3, 927, 000	746, 130
One dam without lock between Sens and Montereau	200, 000	38, 000
12,715 meters (7.9 miles) of wide cut-off, at 238.45 francs (\$45.30) per meter	3, 032, 000	576, 080
Miscellaneous work : protection of banks, dredging, damages, &c.	3, 440, 358	653, 668
	18, 152, 038	3, 448, 887

The total length of the Yonne, in its natural state, between Auxerre and Montereau, is 74.30 miles ; the length of the improved river, measured by the cut-offs, is 67.28 miles ; the cost per mile of improved river is, therefore, \$51,261 ; but if the cost of the reservoir des Settons be deducted, the cost per mile becomes \$48,998.

NAVIGATION OF THE UPPER SEINE.

The Upper Seine extends from Marcilly, at the mouth of the Aube, to Paris ; but the portion between Marcilly and Montereau is generally called the Little Seine, while that between Montereau and Paris is the Upper Seine proper.

During low water the depth of the Little Seine varies from 8 to 12 inches, and that of the Upper Seine from 20 to 24 inches. The greatest flood known had an elevation at Paris, above low water, of 23½ feet.

The slope of the Little Seine in low water averages 14 inches per mile, and that of the Upper Seine 13 inches per mile.

On the Little Seine there is a continuous navigation between the mouth of the Aube, at which place the Upper Seine Canal enters the river, and Nogent, by means of the cut-off between Marcilly and Nogent and the two dams of Conflans and Nogent ; but from Nogent to Montereau there are only four dams, which are used to give artificial flood-waves as far as Montereau. The navigation of the Little Seine is, therefore, not very important, but it is expected that, before long, the same improvements will be introduced here as on the main Upper Seine and on the Yonne. Although the navigation of the Upper Seine, between the mouth of the Yonne and Paris, has always been very important, until September, 1871, it was intermittent for three-fourths of the year and largely dependent upon the artificial floods from the Yonne. This condition of affairs has been ended by the establishment of 12 movable dams between Montereau and Paris.

In examining the question of improving this navigation, it was observed that the effect of an artificial flood-wave was insufficient after it had traversed a distance of 19 miles.

In 1859, 3 dams, in accordance with plans of M. Chanoine, were ordered at Champagne, (one mile below the mouth of the Canal du Loing,) at Melun, and at Evry ; and in 1860, 9 others were ordered at Varennes, La Madeleine, Samois, La Cave, Les Vives-Eaux, La Citanguette, Le Coudray, Ablou, and Port-à-l'Anglais.—(See the profile Fig. 52.)

The 12 large movable dams just mentioned were built between 1859 and 1864, after the system of M. Chanoine, that is, with movable wickets 4 feet wide for the pass, and

automatic wickets 4 feet 3 inches wide for the weir; the interval between two wickets was 4 inches; a single dam, that at Melun, retained for the weir the needle-dam which was already built across the right arm of the Seine. The navigation-passes, which are of masonry, vary in width from 132 to 212 feet; the wooden sills, solidly built into a floor 32½ feet wide, are 10 feet below the level of the pool and 2 feet below low-water line. The new weirs are from 197 to 229 feet long; their sills are 20 inches above low water; the floor, 13 feet wide, is formed of a wooden casing filled with béton, with wooden ties on top, between which is inclosed a masonry pavement; each weir is contained between a pier 10 feet wide, which separates it from the pass, and an abutment which connects it with the bank.

The locks have chambers 39 feet wide, with an available length of 587 feet, so as to receive at least twelve canal-boats or four rafts.

The extremities and the gate-recesses of the locks are built of masonry; but the revetments of the chambers are simply of paving made with rough stones laid dry, resting upon a core of béton placed under water and inclined at an angle of 45°; the dike on the river side, which has a puddled core, is 10 feet wide on top; its outer slope is revetted with rough stone laid dry over riprap. The Port-à-l'Anglais lock has masonry walls with vertical interior faces. The miter-sill is placed at least 5½ feet below the surface of the pool below, which is assumed as horizontal.

The upper surfaces of the dams and of the locks are at least 16 inches higher than the surfaces of the pools above them.

The test made in 1868 of the continuous navigation, which has been mentioned before, in connection with the movable dams on the Yonne, had shown the unreliability of the automatic weir-wickets, and the lack of solidity of the revetments of the lock-chambers, which had been made of rough stones laid dry, and often crumbling under the action of frost. The official order of December 28, 1868, approved of the complementary works which had been considered necessary, and which consisted chiefly—

1st. In lowering the lower miter-sill of the Port-à-l'Anglais lock, and in reconstructing the chamber of this lock.

2d. In the establishment of foot-bridges for manœuvring, made with trestles placed just above all weirs, with Chanoine automatic wickets.

3d. In the consolidation of the paved slopes of the lock-chambers.

4th. In the establishment of a line of telegraph between the dams.

The changes above mentioned were all made by September, 1871, having been delayed by the war and the communist troubles. All the works are firm and solid, and have succeeded perfectly.

The following table gives the principal dimensions of the dams and locks:

Movable dams on Upper Seine.

No. of dam.	Name of work.	Distance in miles.	Lift in feet.	Height in feet above sill.				Lock.		Pass.		Weir.		Remarks.	
				Of weir.			Wickets of sluice.	Width between walls in feet.	Available length in feet.	Width in feet.	No. of wickets.	Length in feet.	No. of— Wickets.		Trestles.
				Wickets of pass.	Wickets.	Trestles.									
26	Bridge of Montreuil.	2.24	4.98	9.54	6.36	.....	.....	39.36	590.40	132.51	31	197.78	43	.....	Weir with movable wickets and foot-bridge.
27	Varennes Dam.	.....	5.48	9.51	6.23	.....	.....	39.36	590.40	132.51	31	197.78	43	.....	Do.
28	La Madeleine Dam.	5.02	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Do.
29	Loing Canal.	8.54	5.37	9.54	6.23	.....	.....	39.36	590.40	149.57	35	197.78	43	.....	Do.—Two passes.
30	Champagne Dam.	9.95	6.53	9.54	6.26	.....	.....	39.36	590.40	83.61	20	198.77	43	.....	Do.
31	Samols Dam.	16.00	6.82	9.54	6.26	.....	.....	39.36	590.40	149.57	35	230.74	48	.....	Do.
32	La Cave Dam.	20.87	6.13	9.58	6.20	.....	.....	39.36	590.40	213.53	50	131.20	35	.....	Weir replaced by needle-dam across right arm of Seine.
33	Melin Dam.	26.41	4.39	9.51	.....	8.04	.....	39.36	590.40	179.42	42	229.93	50	.....	Weir with movable wickets and foot-bridge.
34	Vives-Eaux Dam.	30.08	4.79	9.54	6.26	.....	.....	39.36	590.40	162.36	38	211.56	46	.....	Do.
35	La Citangnette Dam.	34.18	4.66	9.61	6.23	.....	.....	39.36	590.40	162.36	38	211.56	46	.....	Do.
36	Le Couduay Dam.	38.59	5.97	9.61	6.23	.....	.....	39.36	590.40	166.62	39	229.93	50	.....	Do.
37	Ervy Dam.	44.30	5.05	9.45	6.26	.....	.....	39.36	590.40	166.62	39	229.93	50	.....	Do.
38	Ablon Dam.	51.38	6.10	9.54	6.23	.....	.....	39.36	590.40	179.42	42	229.93	50	.....	Do.
39	Port-à-l'Anglais Dam.	58.34	9.84	9.54	6.23	.....	12.14	39.36	615.00	94.14	26	124.31	27	.....	Navigable pass and navigable sluice.
40	Fortifications of Paris.	60.86	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

PORT-À-L'ANGLAIS DAM.

On account of the great distance—fifteen miles—between the Port-à-l'Anglais Dam situated above Paris, and the Suresnes Dam, situated below, and in consequence of the final abandonment of the project of establishing a dam in the city itself, the official order of December 28, 1868, directed the lowering of the lower miter-sill of the Port-à-l'Anglais lock and the reconstruction of the chamber-walls. Consequently a plan for lowering the lower miter-sill $3\frac{1}{2}$ feet, and for bounding the lock-chamber by two masonry walls with vertical faces, was approved May 12, 1869, and the work was executed in 1869 and 1870.

While the work of lowering the lower miter-sill of the lock of the Port-à-l'Anglais Dam was in progress, navigation was kept up through a breach 115 feet wide made in the weir near the right bank, where the channel formerly ran. An official order of February 25, 1870, approved a project presented December 18, 1869, by the engineers, to construct in this breach a sluice for navigation having its sill 2 feet 4 inches below the sill of the pass, and closed by wickets 12 feet 2 inches high. The works were executed in 1870, and were almost entirely completed a few days before the investment of Paris. It was only in 1871 that the sluice could be tried, as also the whole work at Port-à-l'Anglais.

This sluice, 94 feet long, is closed by 26 wickets $3\frac{1}{2}$ feet wide, and having their tops 4 inches below the level of the upper pool, so that a film of water 4 inches in depth flows over them; but it is easy to add a piece of plank to the tops of the wickets, which now have a vertical height above the sill of 12 feet 2 inches, and which would then have 12 feet 6 inches. A foot-bridge, supported by strong wrought-iron trestles, 15 feet 8 inches high, is established above, in order to handle the wickets, which are thrown down by means of a tripping-rod.

The original intention was to establish a foot-bridge above the pass of the Port-à-l'Anglais Dam, which would have had the advantage of permitting the person in charge to cross the river on foot when the dam was closed; but the matter was postponed, and is now altogether abandoned, because in times of ice and break-up it is essential to have the means of opening any part whatever of the dam; for, during the nights of the 7th and 8th of December, 1871, there happened a sudden and exceptional degree of cold, (21°,) and the dams being all up, were encased in ice before it was possible to open anything; but long before the ice melted, the wickets of the pass, which were not preceded by trestles, were cleared, and before the break-up these wickets were lowered, which enabled the cakes of ice to pass through without injuring the dam. With a complication of wickets and foot-bridge, it might not have been possible to have attained the same result.

At the Port-à-l'Anglais Dam a trial is being made of what are called "Papillon valves," which, when placed in the chase of a wicket, open of themselves when the water reaches a given height, and easily close when it falls below it. By using a number of these, a much larger discharge than is now possible could be accommodated before it became necessary to swing the wickets of the weir.

The cost of the work on the Seine has been as follows :

5 locks and dams between Montereau and Melun, at 809,233 francs, (\$153,764).....	4, 046, 416 fr.—\$762, 819
6 locks and dams between Melun and Ablon, at 864,235 francs, (\$164, 205).....	5, 185, 411 fr.—\$935, 228
1 lock and dam at Port-à-l'Anglais.....	1, 580, 733 fr.—\$300, 339
Miscellaneous, dredging, dikes, engineering, &c.....	3, 541, 500 fr.—\$672, 885
Total	14, 354, 060 fr.—\$2, 727, 271
Length of the river, Montereau to Paris, 61 miles.	
Cost per mile of improved river \$44,931.	

MEANS OF TRACTION AND DIMENSIONS OF RIVER-CRAFT.

Under the system of artificial waves all down-stream traffic floated with the wave, and up-stream boats were towed from Paris to Montereau by tugs that pulled themselves along by a sunken chain; above Montereau they were pulled by horses. Since the establishment of continuous navigation both of the above methods continue in use, and steam-boats that themselves carry freight made their appearance on the river.

As the new navigation has just begun, boats do not yet draw all the water available. The average load of a canal-boat is 100 tons, and the

maximum load is 200 tons, while large river-barges carry from 300 to 350 tons.

Rafts are generally 300 feet long, 16 feet wide, and from one foot and three-quarters to two feet in depth. They contain about 120 tons of timber. Canal-boats are 100 feet long and 16 feet wide, and large river-barges are from 115 to 130 feet long, and from 23 to 26 feet wide. (The latter are almost exactly the size of the coal-barges used on the Ohio.)

CONCLUSIONS.

The following are the conclusions of Mr. Cambuzat in reference to the adaptability of the various systems of movable dams that have been tested on the Seine and Yonne:

To sum up, in a system of continuous navigation—
1st. When the lift is small, not exceeding 5 feet, it is advantageous to use Poirée dams, with foot-bridge and needles and a permanent weir, the foot-bridge being raised from 10 to 12 inches above the surface of the pool.

2d. For lifts from 5 to 8 feet, dams should be used whose passes are closed by Chanoine wickets, and whose weirs are surmounted by Poirée trestles and needles, and whose foot-bridges are raised from 10 to 12 inches above the surface of the pool.

3d. For lifts exceeding 8 feet, large wickets worked by the aid of a foot-bridge can be safely used; but in order to guard against surprises in times of flood, of thaws, and of break-ups, the sill of the pass should be sufficiently raised to receive wickets maneuvered by the aid of a boat, and the weir should be surmounted by trestles with needles.

DE LAGRENÉ ON MOVABLE DAMS.

After the above had been translated, a copy of De Lagrené's recent work, "*Cours de Navigation Intérieure, Fleuves et Rivières, Paris, 1873*," was received from the publisher, which contains full information about the Girard shutters, which are noticed in the *Annales*, but are not represented in the plates, and also gives drawings of several other systems. Being the latest work on the subject, it is believed to contain a complete summary of the progress of invention in such matters up to the present date.

The following is taken from this work:

BEAR-TRAP GATES—(AMERICAN SYSTEM.)

The American system, which I am about to describe, is defective in more than one respect, but nevertheless it is interesting to become acquainted with it, because it has probably served as the starting-point in seeking the more perfect methods. (See Figures 1, 2, 3. The drawings of this system, as given by De Lagrené, show, in addition to the two gates, a Thénard counter-shutter, which is placed in the sluice above the gates. As the text sufficiently explains the position and use of this additional member, it has not been considered necessary to redraw the figures, which were taken from Hagen. The circumstances under which the bear-trap gates are used on the Marne are different from those under which they were originally used on the Lehigh, and hence the necessity for the additional shutter.)

At the dam of Neuville au Pont, on the Marne, in the department of the Upper Marne, there is a sluice with an opening of 29 feet 8 inches, which is provided with American gates.

The system is composed of two gates somewhat like those used to close lock-chambers, except that their quoin-posts are horizontal, and are placed across the sluice in a chamber excavated in the floor.

The distance between the two quoin-posts is less than the sum of the width of the gates, so that when they lie down the up-stream gate rests on the down-stream one.

The sill of the floor is 3 feet below low-water, and 9½ feet below the surface of the upper pool.

The length of the gates is 31 feet; they therefore extend 8 inches into the face of each pier, and their motion takes place in a recess, against the edges of which each end of the gates is supported when their movement is ended.

The piers of the sluice are pierced from above to below by culverts, whose ends can be closed at will by means of valves placed in wells.

Above the gates shutters are placed which can temporarily close the sluice. These shutters have their axis of rotation fixed on the floor, and they fall up stream. When they are raised they are held nearly vertical by two retaining-chains fastened to the floor; when they are laid down they are held in a horizontal position by spring-latches, which are fastened on their upper surfaces, and catch of themselves on a stop-bar, which is fixed transversely on the floor. A slight rotation of this bar is sufficient to disengage the latches, and thus free the shutters.

These shutters will at once be recognized as the counter-shutters of the Thénard system, and their assistance is necessary in order to start the American gates, as I will proceed to explain.

In order to shut the sluice, the attendant commences by closing the down-stream valves of the culverts in the piers; he then opens the up-stream valves and disengages the latches of the shutters; the latter are immediately brought up by the current; they close the sluice and stop the flow of water through it; the lower pool lowers and the upper pool rises. This difference of level causes a pressure under the gates, which finally raises them until they meet the wooden heurters placed in the recesses in the piers.

The water, still rising in the upper pool, soon flows over the shutters and fills the space between them and the gates; the former being thus relieved from the pressure that kept them up yield, partly to the effect of their own weight, and partly to the pull of the retaining-chains, and fall down on the floor, where their latches again catch under the stop-bar.

The maneuver of opening is still simpler. It is limited to closing the up-stream valves in the piers and opening the down-stream ones. The water under the gates loses the pressure of the upper pool, and a portion of it flows into the lower pool, and the gates lie down in their chamber.

Experience shows that the gates begin to rise when the fall from the upper to the lower end of the sluice is at least two feet. The time used in closing the sluice depends, therefore, upon the time needed by the river to generate this fall. The maneuver of opening only lasts three minutes, and the gates immediately sink.

The American system, which has just been described, gives rise to the following remarks:

In the first place, the gates are not balanced around their axes of rotation like Desfontaines' wicket, nor are they received by a water-tight cavity, and, even after immersion, they retain considerable weight, which produces a decided moment of resistance.

The calculations which the author gives show that the total weight of the upper gate is 20,840 pounds, and that of the lower or counter gate is 49,756 pounds. The width of the upper gate is 13 feet, and that of the lower gate, measured from its axis of rotation to the axes of the friction-rollers, at its upper end, is 20 feet. When the gates are down, the center of the friction-roller of the lower gate is 5 feet 7 inches from the axis of rotation of the upper gate. When the gates are down the pressure that must be applied to the under surface of the lower gate in order to start them is $709\frac{1}{2}$ pounds per running foot, or $35\frac{1}{2}$ pounds per square foot.

Thus the mere weight of the apparatus requires a difference of level of nearly 7 inches in order to put the gates in motion.

In this system there are other resistances to raising. Both the gate and the counter-gate turn around a wooden axle 31 feet long, which is held by eleven collars of 1 foot interior diameter. This large diameter is the cause of considerable friction. Moreover, between the collars each axle turns in a hollow cut-stone quoin; consequently we find here a double difficulty; in fact, if we leave much play between the axle and the hollow quoin, imitating the practice with lock-gates, we cause considerable leakage, and the loss of pressure of the sustaining water may become too great. If, on the other hand, we reduce the play to fractions of an inch, the least entrance of sand or sediment will cause friction that cannot always be overcome.

Each axle, although perfectly true when the gates are built, may lose its shape after a little while, and by its bending may produce abnormal pressure on some of the collars.

The friction of the axles is not the only thing that must be met. There are besides, seven rollers at the upper end of the counter-gate.

The lever-arm of the lifting force, exercised by the counter-gate, under the gate, is very feeble at the beginning of the movement.

Finally, the leakage under each of the four edges of the gate, and of the counter-gate, must be considerable, and there must be a perceptible loss of pressure in the water that put the apparatus in motion.

I would further remark that the lowering of the gates is not readily done, unless the angle which is made at the top between the gate and the counter-gate when they are up is very obtuse, which makes it necessary to give a great width to these members. This great width increases the resisting moments of the apparatus, as well as the loss of pressure in the water, which is the motive force.

These remarks explain why it has been thought necessary to complete the American system by adding to it a provisional closing apparatus by means of up-stream shutters. These shutters protect the gate from the dynamic pressure due to the current, and, besides, they generate the fall which is necessary to raise the gates, which, as we have seen in what precedes, must be at least 2 feet. The same object could have been attained by a needle-dam, which would also have been useful for other things, as I have explained in the preceding chapter.

The American sluice of La Neuville, considered by itself as consisting of two piers, the floor, the double system of closing, and the down-stream apron of riprap, cost 71,595 francs, (\$13,603.)

The American dam is now completely abandoned, and almost entirely forgotten in America. (Malézieux : Public works in the United States, p. 280.)

The substance of what M. Malézieux says is that, when he asked American engineers about their movable dams, they did not know what he meant. Only the older ones recollected having seen on the Lehigh a movable gate, whose sole object was to produce artificial waves for bringing down timber.

At present the Lehigh has only permanent dams below Mauch Chunk. Above—between Mauch Chunk and White Haven—there are only ruins, which either show the violence of the floods or the lack of experience of their builders.

DRUM-WICKETS WITH INDEPENDENT COUNTER-WICKETS.—CUVINOT SYSTEM.

After studying the Desfontaines system, M. Cuviniot proposed to endeavor to improve it while fulfilling the following conditions :

- 1st. To reduce the length of the counter-wickets.
- 2d. To lessen the loss of pressure in the water that moves the apparatus while it is passing through the drums.
- 3d. To make the wickets independent, so that those which are to be lowered in order to regulate the level of the pool may be chosen at will throughout the length of the dam, so that the cataract may be divided.
- 4th. To obtain stability for the wickets, so that none of them can rise or fall without the intervention of the dam-tender, whatever may be the variations in level above or below the dam.

We will assume for discussion a height of dam of 9 feet 10 inches.

The navigable pass is supposed to be provided with movable apparatus of any system whatever—Chanoine wickets, for example—and the following is the manner in which the inventor proposes to construct the weir :

The permanent sill of the weir is placed at 3 feet 3 inches above low-water.

In the body of the masonry three large cavities or longitudinal conduits are prepared, which are parallel to the axis of the weir, and are arranged as follows, beginning on the up-stream side, (see Plate II :) :

First, a rectangular conduit, 4 feet 1 inch wide, and 6 feet deep.

Secondly, a conduit of a nearly circular shape, whose bottom is likewise 6 feet below the permanent sill, and whose width at the level of the floor is 9 feet 7 inches.

Lastly, a third conduit similar to the first. These three cavities are separated by two division-walls, each $2\frac{1}{2}$ feet wide.

The up-stream rectangular conduit is in constant communication with the upper pool. The down-stream one is always in communication with the lower pool. These two aqueducts, whose tops are covered, perform parts analogous to those of the upper and lower conduits in the Desfontaines system.

The half circular conduit is divided by diaphragms into compartments 3 feet 7 inches long, completely independent of each other.

Two consecutive diaphragms support, in their middle, the axis of rotation of a counter-wicket, which moves in the drum, and describes an angle of 130° . The two arms of the counter-wicket, after inclosing the axis of rotation, are prolonged above the plate that covers the drum, making a bend of 20° . These extensions become two props, which are provided, at their ends, with friction-rollers.

The diaphragms also support the axis of rotation of the wicket. This axis is placed

further up stream than that of the counter-wicket, and at a slightly higher level, so that when the wicket is down it covers the props, and its end rests on the friction-rollers.

Each compartment of the circular conduit communicates with the upper conduit by a hole in the dividing-wall, which always remains open.

Each compartment of the circular conduit is, at will, put in communication with the lower conduit by a hole in the dividing-wall, and this hole is opened or shut by means of a valve, according to the needs of the service.

We can now explain the working of the apparatus. When the counter-wicket turns around its axis of rotation under the influence of the hydraulic pressure, the props take the wicket in reverse, and make it describe an angle of 70° . In its last position, and throughout its movement, the wicket rests upon the rollers of the props.

If the new weir had no other arrangements than those just described, its maneuvering would not differ from that of the Desfontaines weir. The combination by which the independence of movement of the wickets can be assured is yet to be described.

Let us suppose the dam down, and let us imagine that each one of the holes connecting with the lower conduit is closed by a water-tight valve; whatever may be the pressure brought to bear upon the up-stream faces of the counter-wickets, none of them will budge, for there is a play of one-seventh of an inch around the perimeter of each, and consequently there is an equality of pressure on the two faces of each counter-wicket. As soon as one valve is opened the counter-wicket of the compartment, thus relieved from pressure on its down-stream side, will commence moving, and will set up the wicket which it controls. The valve once closed, the equilibrium of the pressure will be immediately re-established on the two faces of the counter-wicket, and the wicket, pressing on the rollers with the pressure due to the lift of the dam, will carry back the counter-wicket to its first position as it falls down itself. In order to permit this movement of lowering, it is necessary, even when the wicket is up, that there should be a water communication between the up and down stream faces of the counter-wicket. Thus, contrary to what happens in the Desfontaines system, the counter-wicket, when the wicket is up, does not make a water-tight connection with its seat, but is supported on a certain number of points, so as to permit leakage around its perimeter.

Maneuvering will then be reduced to that of the valves, of which I have just spoken, and can easily be controlled by means of a rod with projections, which is placed in the lower conduit. By suitably arranging the projections of this rod, all the wickets can be lowered in succession, in whatever order may have been determined in advance.

The raising will be done in inverse order.

The axis of rotation of each valve is provided with a projecting finger, (Fig. 65.) whose direction is parallel to that of the valve. This finger, when pushed by the projection, remains horizontal while the projection rests upon it.

When the projection is drawn back by a movement of the rod, the valve, which is now free, is swung down by the counter-weight, which is fastened to it for this object. It has been foreseen that a case might occur in which this counter-weight would be insufficient to overcome the adhesion of the India-rubber facing and to cause rotation.

A counter-finger, likewise fastened to the axis of the valve, and at right angles to the finger, receives the push of the tripping-rod through a stud, which forms a kind of counter-projection. When the movement has once begun, the counter-weight will always suffice to swing open the valve, and the counter-finger will not be in the way of the advance of the bar while the movement of lowering the wickets is in progress.

This brief description already shows that, by placing the upper and lower conduits outside of the drums, it is much easier to increase their cross-section; this is an important consideration in order to avoid loss of pressure.

It can also be seen that the relative positions of the wicket and the counter-wicket lead, as a first consequence, to the possibility of a reduction of the length of the latter. In fact, for a dam constructed under conditions similar to that at Joinville, a lift of 6 feet 7 inches compels the adoption of a counter-wicket descending to 8 feet 2 inches below the permanent crest. In the system described in this chapter, the counter-wicket, describing an angle nearly double that described by the wicket, can furnish the same quantity of effective work with a shorter length, and the depth of the excavation in the masonry is thus diminished about 2 feet.

The weir is contained between two piers or abutments, which are penetrated by the two rectangular conduits; they end in aqueducts, which pass through the entire length of each bounding wall, and are perpendicular to the direction of the dam. These aqueducts have three valves: The first, commencing up stream, is between the opening for taking water and the end of the raising-tube; it is seldom closed, except during floods of muddy water, and during the cleansing operations, which will be described next. The second valve is between the two conduits, and is generally closed. Lastly, the

third valve is placed below the emptying-conduit, and is always open, except in rare cases.

As a rule, the up-stream conduit is left in constant communication with the upper pool at both ends, and the lower conduit in communication with the lower pool.

The only work to be done to regulate the level of the pool consists, as I have said, in shifting the tripping-rod.

If the upper rectangular conduit should receive sedimentary deposits, it is only necessary to close the upper valve of one of the piers and to open the middle valve of the same pier. A very rapid current will be formed in the conduit, and will clean it out. A similar maneuver will assure the cleanliness of the lower conduit.

However, deposits, if they should occur, need not be dreaded, since they will be localized in the two conduits at a distance from the drums, and they could have no injurious effect upon the march of the counter-wickets, except by slightly diminishing the cross-section of supply or discharge.

The establishment, above the wickets, of a line of trestles, carrying a foot-bridge, is demanded by general reasons which apply to all wicket-dams; in fact, it is important to give the lock-tender an easy circulation from one shore to the other. In addition, the line of trestles permits the construction of a temporary dam for repairing, either with the view of momentarily replacing the wicket-dam by one of needles, or of moderating the current by means of a screen of needles placed in front of lowered wickets, or of regulating the inclination of the wickets, as I have explained in speaking of the Joinville Dam. In conclusion, although a foot-bridge above is not indispensable for the Desfontaines or the Cuvinot Dam, I think that there ought to be no hesitation about establishing one.

The author then calculates the amount of the forces that act on the different parts of the apparatus, selecting the wicket nearest the pier, as in this system this should be the last wicket raised. Even in this case there would be no difficulty in raising the wicket. There may be some trouble with the friction-rollers, but the proper test of the system is to try it, which, apparently, has not yet been done.

He suggests that the masonry in the weir might be greatly reduced by omitting the upper and lower conduits, and opening direct communication between the drums and the upper and lower pools. The objection to this is that the drums might be filled with sediment and vegetable matter brought down by the current.

POIRÉE NEEDLES.

M. De Lagrené states that experiments with needles having sections of the form of regular or semi-regular hexagons have shown that, owing to the bending of the needles and to practical difficulties in placing them in the positions which theory would indicate, it has been decided to give up these sections and to return to the square. He suggests for trial needles shaped like a T, which are to alternate with square needles.

This solution, however, does not appear altogether satisfactory; and he also proposes for trial needles whose upper sides are slightly rounded and are provided with strips of India-rubber, with the view of overlapping adjacent square needles. The upper portions of T-needles and of those with India-rubber flaps ought to be square, but this will not be objectionable, as the greatest leakage is nearest the sill. He also suggests the use of hollow needles made of planks, for which he gives the necessary calculations. Such needles would have to be handled by mechanical means. Two such needles were tried in the pass of the Melun Dam, in September, 1872, when there was a fall of 7 feet 2 inches, and there was no difficulty in putting them in place. Sections of these forms are given on Plate 10, Fig. 62.

The author thinks that intermediate supporting-bars are necessary in high needle-dams, and states that since their adoption on the Lower Seine, in 1868, the breaking of needles has almost entirely ceased.

M. Cadot suggested that it might be advantageous to have trestles

with two stories of needles. He proposed to fasten pins to the upper legs of the trestles, a little below the tops of the lower needles, and to place on them the sill for the second story of needles. This sill should be of T-iron, hooked on to these pins, and should be put in place after completion of the lower story of needles. This plan would make two foot-bridges necessary at different heights, and it might happen that the removal of the upper story of needles would not sufficiently lower the water to expose the lower foot-bridge. That, however, might be remedied by limiting the two-story arrangement to a part of the dam, and making the rest of long needles. If the removal of the latter did not suffice to uncover the lower bridge, the needles of the lower story would have to be removed by a boat. This plan, although not yet in use, seems to promise good results.

SHUTTERS WITH PONTONS.—KRANTZ SYSTEM.

The plan of dam proposed by Chief Engineer Krantz in 1868, and now in course of construction on the Lower Seine, at Port Villev, suggests new combinations, which I will explain from the description of the inventor which accompanied his plan.

M. Krantz first decided on the principle that every movable dam should satisfy the following conditions:

1. It should be manœvered by the aid of the natural forces of the water-course, properly brought in play, and without exposing the attendants to any risk.
2. The whole apparatus should at all times be subject to human control.
3. It should, spontaneously, correct the slight changes of level in the pools, and should rarely require the intervention of man.
4. It should only be composed of strong parts, capable of resisting violent shocks.
5. It should only require for its establishment constructions similar to those which are habitually built on our rivers.
6. It should be sufficiently tight.
7. It should be applicable to lifts greater than those of the present dams.

Then comes the description, which I copy *verbatim*, allowing the inventor to speak for himself:

"The dam which we are about to describe is planned to sustain a lift of 9 feet 10 inches.

"When lowered, it should not project above the horizontal plane drawn 2 feet 7 inches below low-water.

"We could easily have chosen a different relief, as the system is well adapted to it. But, on the one hand, the depth of 2 feet 7 inches is that of the navigable passes constructed on the Lower Seine, particularly at Suresnes; and, on the other hand, a lift of 9 feet 10 inches is that of our highest needle-dams. By choosing these dimensions we render the comparisons which we intend making more simple and more conclusive.

"The essential parts of the dam are: (Plate 12, Figures 67, 68, 69, 70.)

"1. The lockette, (*écluse*, or little lock,) by which the water which serves to work the apparatus is distributed under the proper pressure.

"2. The dam proper, which includes the pouton with the upper wicket, and its valves, and the water-conduit.

"The lockettes are placed at the ends of the different sections of the dam, each of which may have as great a length as 300 feet.

"Their number, and the spaces between them, depend upon local circumstances, with which we have no concern at present.

"As to the dam, whatever be its importance, it is divided into elements 9 feet 10 inches long, which act simultaneously under the action of the same forces, while at the same time preserving a mutual independence.

"The lockettes are of metal, and rest upon a masonry base. They are hollow, and communicate with the upper and lower pools.

"Two sets of valves, with vertical axes, placed near the ends, permit at will the interruption or the establishment of communication between the central part of each lockette and the pools.

"Whence it follows that the lockette is, in fact, what its name indicates—a kind of lock, of small size, in the chamber of which one can, at will, by a suitable movement of the valves, maintain either the level of the upper pool, or that of the lower pool, or an entirely different intermediate level.

"The side wall of the lockette which adjoins the dam is pierced at the height of the conduit by a rectangular opening, through which flows the water destined to raise the apparatus, or by which it escapes when the dam is to be lowered.

"This opening is $1\frac{1}{2}$ feet long and 2 feet wide, and has a surface of 23 square feet.

"The conduit extends under the entire length of the dam. It is connected at its ends, by means of the opening just mentioned, with the chamber of each lockette.

"By them it can be put in communication sometimes with the upper pool, sometimes with the lower pool. By them it can receive water coming from a level intermediate between those of the two pools.

"The opening which forms the communication between the chambers of the lockettes and the conduit is always clear. This communication is never interrupted.

"The conduit is trapezoidal in form; its down-stream wall is vertical, and stops 2 feet 7 inches below low-water; its up-stream wall is formed by a part of a cylinder, concave down stream, and described with a radius of 14 feet; this wall rises to 3 feet 4 inches below low-water.

"The width of the conduit on the bottom is 14 feet 9 inches; its depth below low-water is 8 feet 7 inches.

"The section of the conduit of a dam of the importance of that which we have described is 122 square feet.

"The office of the conduit is to distribute in all parts of the apparatus the water of different pressures, which is the effective force.

"We will now examine the appliances by means of which this force acts to work the dam.

"The essential organ is the ponton.

"It floats in the conduit and receives the immediate action of the water.

"The ponton is empty, and the volume of water which it displaces constitutes an ascending force of such a character as to suppress entirely, or partly, the weight of the apparatus.

"Its general form is a rectangle rounded at its ends.

"Its dimensions are :

"Length, including borders	9 feet 2 inches.
"Width, at right angles to dam	13 feet 5 inches.
"Thickness	3 feet.
"Weight, including iron-work	14,405 lbs.
"Volume of water displaced	21,839 lbs.

"Each ponton, then, tends to rise with a force equal to 21,839 lbs. — 14,405 lbs. = 7,434 lbs.

"We will see later under what conditions this ascending force acts.

"Each ponton is fastened by two hinges, with horizontal axis, placed a little below the upper down-stream angle of the water-conduit.

"It oscillates around this axis without passing the extreme positions, which will be indicated afterward.

"At its upper up-stream angle the ponton has an axle to which the upper wicket is fastened and around which it turns.

"We add, that the ponton is solidly built, of strong sheet-iron, and is water-tight, and a man-hole permits a workman to descend to examine the riveting.

"Besides, there is another orifice, through which a pump can be introduced to remove whatever water has penetrated through the joints.

"When the dam is raised, the upper wicket is inclined down stream at an angle of 30° with the vertical. It extends downward to 5 feet 4 inches below the level of low water, and upward to 9 feet 4 inches above the same level.

"Its dimensions are as follows :

"Length parallel to the dam	9 feet 10 inches.
"Vertical height	14 feet 2 inches.
"Height measured on the incline of 30°	16 feet 4 inches.
"Weight, all told	8,515 lbs.

"When the dam is raised the level of the pool is 6 inches, measured vertically, above the upper crest of the wicket; from this results a superficial overflow over the entire length of each wicket, and consequently over the dam.

As we have said, the wicket is fastened at the upper angle of the ponton by means of hinges, and each point moves in a plane perpendicular to the dam.

"The axis of rotation is placed at 1 foot 4 inches above the center of pressure of the water as calculated for the normal lift.

"In the upper part of each wicket there are three Papillon valves, (Fig. 69.) These valves corresponding to the shape of the wicket, are each 3 feet 1 inch high, and 2 feet wide. Their upper edges are 4 inches below the top of the wicket.

"Designed for automatic movement, they are fixed to a horizontal axis of rotation placed at 1 foot 4 inches above their lower edge.

"They are checked in their movement of rotation by a chain fastened to the valve itself, which does not permit them, while opening, to fall below a slope of 15° with the horizon.

"The retaining-chain has a counter-weight, whose use will be explained further on.

"We will further add, that the pontoons have wooden borders at their ends.

"That they are separated by 8-inch braces, which serve as the upper connection of the frames and walls of the conduit, while they are fastened below to a heavy beam.

"That the line which joins the centers of two axes of rotation makes an angle of 100° with the plane of the wicket when it is up, and consequently makes an angle of 10° with the normal to this plane.

"And that two stops firmly fastened to the metal frame-work limit the play of the apparatus.

"This brief description enables us to take up the description of the movement and the calculation of the forces developed in the different positions of the dam.

"The first position to be considered is that of the dam down. (Plate 12, Fig. 63.)

"The ponton is then submerged in the conduit. The wicket lies horizontal, and covers it, and the Papillon valves are likewise horizontal.

"The river flows freely, and there is no sensible difference of level above and below the dam.

"In this condition there is no pressure, and the apparatus is only urged upward by the buoyant effort of the water displaced by the ponton; likewise its own weight is the only force which tends to press it down.

"Then the volume of water displaced is $35\frac{1}{2}$ cubic feet per running foot, which corresponds to an upward pressure of 2,214 pounds. This pressure acts at a distance of 6 feet 11 inches from the axis of rotation, and has in reference to this axis a moment of 15,254 foot-pounds.

The weight of the iron-work, wood, and appendages of the ponton is 1,462 pounds, and as this weight acts at a distance of 7 feet $4\frac{1}{4}$ inches from the axis of rotation, it gives a moment of 10,790 foot-pounds.

"To which must be added the portion of the weight of the wicket which rests upon the upper hing. It is 255 pounds, and acts at 13 feet 5 inches from the axis of rotation, giving a moment of 3,420 foot-pounds. This added to that of the ponton gives a total of 14,210 foot-pounds.

"Thus the moment of the buoyant effort exceeds that of the weight by 15,254—14,210 = 1,044 foot-pounds.

"Will this excess of force be sufficient to overcome all the passive resistances of the machinery, such as friction on the axis, and on the sides, weight of the water, &c.? We do not think so.

"But if the ponton should tend to rise under this feeble impulse, a few pounds of ballast would suffice to hold it in its place.

"We may, therefore, until experiment has decided the question, retain these distributions of weights, which have the incontestable advantage of making the machinery very sensitive at the start."

A difference of level seems necessary in order to put in motion the apparatus as described. The question is how to secure this while the pass remains open.

"Two ways of overcoming this difficulty present themselves.

"In the first place, it is possible so to increase the volume displaced by the ponton as to make an upward moment sufficiently great to overcome all the resistances to motion.

"But this would lead to a very considerable lowering of the bottom of the water conduit.

"Moreover, the ascending force thus created becomes an obstacle when the dam is to be let down or is to be kept down.

"Another remedy must therefore be sought.

"It consists in borrowing the water necessary to start the apparatus from a reservoir established on the bank, which fills itself from the upper pool when the latter is created.

"Thus, water of a pressure much greater than is needed for getting under way can be obtained at a nominal cost.

"It is important to bear in mind that the conduit being already full of water, the reservoir need only provide for filling the empty space caused the movement of the pontoons, and for the loss of water through the joints.

"The vacuum left in moving the ponton is 21 cubic feet per running foot, or 6,300 cubic feet for a length of 300 feet.

"If an equal volume be added for the waste through the joints, we see that a reservoir of the capacity of 13,000 cubic feet will be more than sufficient.

"This reservoir, which communicates with the upper pool, ought necessarily to be at least 10 feet higher than the lower pool.

"It will generally be filled without cost, since all that is necessary is to put the reservoir in communication with the upper pool, and to preserve the water which will thus be stored up.

"From what precedes, we believe that we may conclude that the raising of the dam will take place without difficulty."

The calculations of the forces acting on the dam at different stages are omitted. They show, however, that in low water, when the difference of level between the two pools is greatest, there will be an upward pressure of 4,363 lbs. on each of the stops that prevent the ponton from rising too high. This pressure diminishes as the water rises. These stops are placed at 13 feet 9 inches from the axis of rotation.

"Whichever of these figures [those for various differences of level] is considered, it is impossible to avoid seeing that they will naturally make the security of the stops a matter of doubt.

"It is for this reason that in the face of the lockette which looks toward the dam an opening has been made, which may be unmasked at will. By suitably arranging this opening and regulating the introduction of water into the chamber of the lockette, a less level may be substituted for the level of the upper pool, and the upward pressure on the ponton may be lessened as much as may be judged proper."

It may readily be shown by calculation that when the conduit is connected with the lower pool, the dam will fall, no matter what may be the stage in the river.

"In what precedes we have supposed that the upper wicket, as it rises, will turn of itself on its axis, resting against the suitably-rounded edge of the metallic frame.

"But it is important to examine into the conditions under which the movement can be completed.

"At the start, and before the establishment of back-water, the only force opposed to the turning of the wicket is the friction of its gudgeons in their boxes. This friction, which amounts to about 18 per cent. of the pressure, acts at the extremity of a lever-arm of $2\frac{1}{2}$ inches, and cannot successfully resist the weight of the wicket, which acts at the end of a lever-arm of 16 inches.

"The wicket, therefore, will at once begin to swing. But, as it rises, the obstacle which it opposes to the flow of the water will increase, back-water will form above, and by new pressure will give rise to new elements of resistance.

"On the other hand, the lever-arm of the resultant of the weights will diminish in consequence of the increasing inclination of the wicket to the horizon. There is, therefore, reason for dreading lest between these two groups of forces, one opposed to swinging and increasing in amount, and the other acting in the opposite direction, but decreasing, a momentary equilibrium should be established, whence might ensue a stoppage of the movement.

"The most critical moment is evidently when the upper edge of the wicket, after reaching the level of the lower pool, commences to rise out of the water. Until then the pressure acts uniformly on the upper surface of the wicket. When the wicket begins to emerge, its upper part is relatively lightened."

Calculations show that when the back-water above reaches a height of about 4 inches, the wicket will no longer have a tendency to turn.

"If, then, there were no other means of throwing the center of pressure below the axis of rotation, the movement of the wicket would not continue, unless, by the addition of suitable weights, the superiority were assured of the moments of the forces that act to revolve the wicket over the resisting moments.

"But the play of the Papillon valves comes in, and this valuable organ spontaneously causes the displacement of the centers of pressure.

"In fact, the Papillon valves, which, like others, are uniformly loaded on the upper faces, swing open, and practically lessen by 3 feet $1\frac{1}{2}$ inches the length of the wicket above the axis, which is under pressure from the upper pool.

"By this means the center of pressure is suddenly thrown below the axis of rotation, and the moment of these pressures, acting in the same direction as the weight, accelerates instead of retarding the swinging movement."

From calculations which we omit, the inventor concludes, "that the Papillon valves will swing of themselves, before the level of the water held back is raised one foot in vertical height above the upper edge of the wicket.

"In order to make sure that the valves will close, it is better to introduce a new element of action, only it is necessary that the weight, from which the additional force is obtained, should be so placed that, while aiding the valve to shut, it may not hinder it from swinging open. This result is easily obtained by fastening a ball to the last link of the holding chain. When the valve is shut it is supported by the ring to which

the retaining chain is fastened. When the valve is swung open it pulls upon its upstream end, generating a moment of 1.3 foot-pounds for each pound of weight.

"It is therefore practicable, by the aid of this very simple arrangement, or by the aid of a spring, to facilitate the return of the valve, and to make it as sensitive in closing as in opening.

"Experience will very soon show the amount of additional weight to be used for this purpose.

"But we may conclude from what precedes that the valves may easily be arranged so as to swing when the level of the water rises to one foot above the top of the wicket, and to close when the water is even with the top.

"Except in case of a flood, the level of the pool will then oscillate around a mean position of 6 inches above the top of the wicket, and will not vary more than 6 inches in either direction.

"In what precedes we have investigated the movement of the whole dam, then that of the wickets, and lastly that of the valves, calculating for each the forces generated, and deducting from these calculations the practical means of providing for the proper working of the machinery under the assumed conditions.

"It appears to us, from this discussion, that the moveable dam which we have described ought to work satisfactorily, making due allowance for the slight changes which experience will indicate.

"It only remains to examine into what will happen in particular cases.

"As a rule the wicket should only move when started by man's intervention. The valves alone ought to suffice for maintaining automatically the level of the pool, when the oscillations are not too great.

"If, then, a rise of any importance should occur, the dam should be worked in time to pass the wave, by totally or partially obliterating the relief of the works."

The inventor concludes that if a sudden rise should come at night, of 6 feet, for example, the wicket will spring spontaneously, and no injurious effects will accrue. The same thing will happen if the wickets are struck by heavy floating bodies, but they will rise again after these bodies have passed by.

"Before closing this chapter we ought to call attention to a very valuable property of our dam, its power of maintaining itself in any position intermediate between the extreme ones of being entirely raised or entirely lowered.

"In fact, by following closely the description of the movement of raising, it will be seen that the ponton can only rise in proportion as the conduit is filled.

"If, then, by a suitable play of the valves the introduction of water is limited to what is strictly necessary to replace losses by leakage, the level in the conduit ceases to rise, and the upward travel of the pontons, and that of the wickets also, is arrested. The wickets will then remain stationary, oscillating feebly around the mean position where we may choose to hold them.

"It is equally practicable, in the opposite case, to limit the discharge to what is necessary to pass the water that enters through the joints of the apparatus, and when that is done the ponton will cease to descend.

"It follows from this that it is practicable to give the dam such an intermediate position as may be thought suitable to the state of the river.

"In order to secure definite ideas and to substitute figures for general formulas, we decided to assume such conditions as would make it possible to get the exact comparisons of cost which we desired.

"It is for these reasons that in what precedes we have assumed that the dam creates a lift of 9 feet 10 inches, and has an open pass of 2 feet 7 inches.

"But these dimensions are not essential, and others could easily have been taken.

"If the fall and the pass are diminished, we obtain a smaller dam, and no difficulty would arise that could throw any doubt on the good working of the reduced apparatus.

"It might, however, be asked whether, bearing in mind its necessarily high cost, it will be a useful expenditure for small lifts. This is doubtful.

"But it is equally applicable to still higher lifts, and how much may the lift be increased? This is what it is important to examine.

"The pressure of water and the weight of machinery increase rapidly with the lift, but the counter-pressure and the counter-weights increase yet more rapidly; whence it follows that the river always furnishes us more auxiliary than adverse forces, and that in this contest, in which we limit ourselves to taking command and providing the field of battle, victory ought definitely to remain with us as long as any contest is possible. And the contest will only cease to be possible when the magnitude of the forces developed becomes such that we can no longer transmit them by our machinery.

"It is, then, certain, thanks to the progress made in metallic constructions, that this transmission is possible, within very extended limits, and that dams of 13, 16, 20, and

23 feet of lift would not, as far as concerns construction, give rise to any insoluble difficulty.

"This is evident as regards the valve, the ponton, the lockette, and equally so as to the journals, which will not have to support loads at all comparable to those borne by the journals of large hydraulic wheels. In short it will be no more difficult to pass from a dam of 10-foot lift to one of 20 foot, than it was to pass from steam-engines of 300 horse-power to those of 600."

M. de Lagrené adds that he would have liked to have made some additional calculations upon the forces developed in different positions of the Krantz Dam, but that he thought it better to wait until the Port Villez Dam could be tested, and therefore he contents himself with reproducing the inventor's description.

DAM WITH HINGED GATES—CARRO SYSTEM.

M. Carro, an engineer connected with the Marne navigation, has proposed a system of dams which, like the preceding system, obtains its motive-force from the water-course on which it is built, but which, according to the inventor, may be applied to lifts for which the Desfontaines system will not answer. The new apparatus appears to have the additional advantage of serving as a regulator, as it will lower itself little by little as the discharge of the river increases.

The following is the description given by M. Carro in a pamphlet published in 1870 :
 "The apparatus which we propose, (Plate 13, Figs. 71, 72, 73,) when reduced to its simplest form, comprises two gates, which are connected on top by hinges, and rest on wooden axles terminated by journals provided with rollers. The gates roll upon rails placed parallel to the thread of the stream.

"Links fastened to the lower gate, below the middle, are also fastened by a second articulation to fixed points distributed along a right line parallel to the crest of the dam, and at right angles to the current. A depression or chamber, from 1 foot 8 inches to 2 feet in depth, is prepared under the gates.

"When the latter are raised so as to form a dam they have the appearance of an isosceles triangle, (Fig. 71,) whose apex is the crest of the weir. In order to remove the obstacle which they present to the current they are made to slide, or rather to roll in opposite directions, until they lie down flat on the sole, and only make, as it were, a flooring to cover it. The two gates may therefore be considered as a single one, jointed at a fracture in the middle, which works under the pressure of the water when the dam is maneuvered.

"If we consider the gates in the position last examined, and suppose that by a special arrangement of valves, of which we will speak further on, we put the chamber which they cover in communication with the upper pool, the water introduced will exercise, by virtue of the difference of level above and below the dam, an under pressure represented by this difference of level, or, more exactly, by the living force of the current.

"The upper gate will have its lower surface at least as much pressed as its upper one. As to the lower gate, it will necessarily receive an under pressure; which will compel it to rise, so that, while the links turn around the joints at their extremities, the partly rounded axle of this gate will move on a level with the horizontal plane of the sole. The rotation will continue until there is an equilibrium between the water-pressure pushing the gate, and the reaction of the links, and of the rails on which the rollers travel, with which the ends of this axle are provided.

"To accomplish the inverse operation, it is only necessary to interrupt the communication of the gate-chamber with the upper pool and to connect it with the lower one. The water contained in this space, which is higher than the level of the lower pool, will flow off; the under pressure on the lower gate will disappear, whilst on the other hand the equilibrium on the upper gate will be destroyed, the moment of the greater force will throw the latter down on the floor, and in its movement it will drag down its down-stream partner, making it roll on the iron track. Such is the principle of the proposed machinery, on the subject of which we will now enter into detail.

"The preceding description shows that the upper gate opposes no resistance to the raising of the apparatus, since it is in equilibrium, if not even under a slight lifting pressure, due to the slope of the water between the head of the supply-aqueduct and the orifice by which it communicates with the chamber." (Note by M. De Lagrené: "This demonstration needs further development, and particularly a calculation of moments.")

"It must likewise be remarked that when the apparatus works under full pressure the upper gate only plays a passive part, and its influence is only felt at the moment of the partial or complete lowering of the system.

"If we suppose the apparatus entirely down on the sole, then the upper gate opposes

the spontaneous rising of the lower one, and but for it the latter would yield to the action of the current on account of the position of its axis of rotation under the middle of its length.

"This position of the axis in the middle of the gate explains how the latter rises when it is under the influence of the under pressure.

"In fact let C (Fig. 74, Plate 13) be the position of the center of under pressure on the lower gate, being at its middle when the latter is completely immersed. If this point C is on the up-stream side of the joint D of the link, the force of under pressure R will be decomposed into two other parallel but opposing forces P and Q respectively, applied to the points D and B. The force P will determine the rotation of the link around the point K, while the force Q pressing the lower end of the gate on its railroad, will compel it to rise.

"We have therefore chosen for the point of attachment of the links a point whose position is always on the down-stream side of that taken by the center of the under pressure in the different phases of the ascending movement of the gates. By supposing the chamber constantly full of water under the pressure from above, we know that the point of application of the under pressure always lies between the third and the middle of the lower gate, the first position corresponding to the extreme case where there is no counter-pressure of water, and the second to that in which this gate is completely submerged below the level of the lower pool. If, then, we place the joint D of the link at one-third of the gate from its foot, we will be sure that the center of under pressure will always be above this axis, and that it will only coincide with it in the case when the sole below is uncovered.

"The last-mentioned position is the one which must be chosen for a weir whose permanent part will not always be submerged by the water of the lower pool.

"In a navigable pass, where is always a counter-pressure, there is no inconvenience in placing the point of attachment of the link even at the center of the under pressure, always keeping in mind the counter-pressure of the water below.

"In the machinery in question, the pressure is reduced to an effort of extension, which is met by ties or links, whose number may be multiplied at discretion, but two will evidently suffice for each lower gate.

"These links may be attached to a sill fixed on the sole, whose tendency to be raised or torn out can easily be counteracted.

"To accomplish the same object we might have recourse to iron rails extending across the gate-chambers, and resisting the pull of the links by utilizing the weights of the masonry of the side-walls, which by this means are solidly connected. This second arrangement is the one shown on Plate 13.

"When the two twin gates lie on the sole it is evident that however small be the play left between the upper one and the surface of the paving, the current may penetrate within and raise it. It would not then be practicable to keep it under water if this tendency were not met by a special arrangement.

"This tendency to rise may be overcome by replacing the ordinary rails by double-T irons, forming channels in which the journals at the end of the axles can slide.

"However, we have chosen another means, which offers us more security against the introduction of sand under the gate, which may, in certain cases, paralyze the movements.

"In the arrangement finally adopted the upper gate is composed of a square frame, which is only partly covered, all the lower part being left open. A third gate, which we will call the screen, is placed above, which is fastened by hinges to a sill fixed on the sole. This screen falls down stream, covering the empty space left in the lower part of the upper gate; rollers on its upper cross-piece facilitate the sliding on this upper gate, and the latter raises the screen as it comes up in the upward movement of the crest of the dam.

"The introduction of this new organ does not at all change the working of the apparatus. The water, which penetrates with its living force into the gate-chamber, exercises a pressure on the lower gate, which it compels to move, whilst the upper gate and its screen find themselves in a manner inclosed in still water, being pressed equally on their two faces, and consequently opposing no resistance to the movement derived from the lower gate.

"A dam, or a sluice, is provided with a series of couples of twin gates like those which we have briefly described.

"All the lower gates, which form one part of the movable apparatus of the dam, are simultaneously subjected to the influence of the same under-pressure. It nevertheless may happen that the friction of a hinge, resulting from insufficient play in the articulation, may make a couple of gates a little more sluggish in moving than others; or, it may even be granted that the interior current, which is created at the moment the supply-valves are opened, will not make the under-pressure instantaneously uniform under all the pairs of gates, and that they might have a tendency to rise successively.

"If these pairs of twin gates were independent of each other, the beginning of their

rising under the hydraulic pressure might possibly not be simultaneous throughout the length of the dam; there would be reason to fear that one of them in rising would separate from the neighboring pair, an opening would then be formed between the two, which would allow the inclosed water to escape, and by destroying the under pressure would cause the manuever to fail. But it is easy to prevent this lack of coincidence in the different phases of the movement.

"The conditions of equilibrium under which the gates are placed are, as we have said, sensibly the same, and in practice can differ but slightly. If, then, we suppose that we connect by transverse beams the gates that fall the same way, they will be stiffened, and will simultaneously obey the forces which tend to move them.

"Is there any danger that the axle of the two hinges which connect on top the upper and lower gates of the proposed system might not be perfectly rectilinear, and that in consequence passive resistance might result of such a character as to interfere with manuevering? We have taken the precaution to give to these hinges a single axle of rotation, so that each pair of gates, considered separately, cannot give rise to such an apprehension.

"As to the straightness of the line formed by the series of independent axles, there is no reason to expect that it can become so crooked as to prevent the simultaneous movement of the shutters. The transverse beam which keeps them stiff is fastened by bolts in the spaces which separate the neighboring pairs. A certain amount of play results, which permits these gates to have a slight transverse displacement, analogous to that of a car in the space between the rails of the road on which it travels.

"In addition, we can attain the same end by suppressing the transverse beam, which binds together the different couples of a bay, and giving a single axle of rotation to the upper joints of all the links, thus securing the same rigidity.

"The play left between the gates of two adjoining pairs may be as limited as possible, and the direction given by the rails to the movement of these gates reduces its variation to narrow limits. However, it is worth while to remark that the vacant spaces between the upper gates will always act in the opposite way to those of the lower gates, and that if one set tends to interfere with manuevering the other will assist it.

"Two water-conduits at the ends of the weir, or of the pass, are unnecessary, as a single one will undoubtedly suffice for the working of the machinery. The second one would probably only be indispensable where the river to be canalized had considerable width, which would cause a longer length of weir than is usual. However, if we can avoid making a second conduit, we think that it would be well to reserve in the body of the opposite bounding-wall an emptying-conduit, in order to have the means of creating in the chamber the scour of water necessary for cleansing it.

"If, in a long dam, there were reason to dread the effect of warping, it would only be necessary to divide the dam into several bays, formed of gates firmly fastened together. Small and narrow piers, separating the different groups of gates, and pierced to provide communications between the gate-chambers, would act as partitions, and make them independent.

"The division of the dam into several bays would have the additional advantage that, in the event of future repairs, it would assist in the establishment of coffer-dams to isolate the bay where work was to be done. Repairs could be made while the dam was working, since the two segments could be fed respectively from the two ends.

"One of the characteristics of the proposed apparatus is, that it permits any desired change in the height of the dam.

"If a flood should make its appearance, it would be easy to partly lower the gates, and thus retain the water of the upper pool at a sensibly constant level until the moment came to make the relief of the movable part disappear entirely.

"In fact, the system of valving, first thought of in order to make and break alternately the communication between the gate-chamber and the upper and lower pools, consists of two valves, placed in the longitudinal aqueduct for supplying water, one above and the other below the transverse opening. Then, if the supply-valve be slightly lowered, and the discharge-valve correspondingly raised, the water in the space between them will soon, in consequence of this manuever, take a level intermediate between the upper and lower pools, the interior pressure will diminish, and the upper gates will push down their partners until a new state of equilibrium is produced, and their movement ceases.

"A few turns of a wrench will then suffice to enable one to vary at will the position of the crest of the weir.

"We have seen that the two valves always work in contrary directions, that is, when one rises the other ought to lower; and that the play of the machinery depends rather on the relative than on the absolute size of the openings. It follows from this that by connecting the rods of the two valves by a balance-beam, as M. Desfontaines has done, we can simultaneously cause the double manuever by means of a single screw, moved by hand.

"However, we think that in the case in question it is preferable to use another kind

of valving, which has the property of being automatic, and better performs the duty of regulating the level of the pool.

"A weir, and especially a navigable pass, constructed according to the system which has just been described, will have the advantage of not causing at the moment of opening a scour dangerous to the preservation of the lower part of the sole. The crest of the movable apparatus, by gradually lowering along its whole length, will cause a less dangerous superficial current."

We see from this discussion that the proposed system is distinguished by its simple and ingenious arrangements, whose combination appears rational. M. Carro besides introduced, in 1872, some improvements on the first plan, which has just been described.

For fear that a variation of pressure in the lower conduit might cause a warping in the girders, which connected together the different pairs of gates, he modified this method of consolidation. The method which he finally adopted will, according to him, permit the use of sufficiently long bays, even without the intermediate piers to act as partitions. Besides, in the new arrangement the screen which was to rest on the upper gate is suppressed, and replaced by a simple iron plate, a sort of permanent joint-cover, like that which covers and holds the end of the breech of a Krantz wicket when it is down. (Plate 12, Fig. 68.)

But, as I have already said, it is only by trial that the merit of any new system whatever of movable dam can be determined.

Reference has been made in the above to the automatic valves invented by M. Carro, in order to regulate the level of the upper pool. These valves are described by M. De Lagrené in a preceding chapter, from which the following is taken :

SELF-REGULATING TWIN WICKETS.

I have already shown that a wicket which turns around a horizontal axis can be centered in such a way as to swing when the pool is slightly higher than a given level, but that it will not lift itself up until after a considerable lowering of the pool below this level. Such a wicket is not automatic.

But it is possible to couple two wickets together in such a way that the combination shall have this property.

Suppose, for example, a pier or an abutment, pierced by an aqueduct parallel to the axis of the stream, and in this aqueduct two wickets suspended, each with a horizontal axis, but so connected together that when one is vertical the other is horizontal. These wickets are centered in such a way that their center of gravity is nearly in each axis of rotation. The property which one has of swinging can be utilized to set up the other, and if in the pier or abutment the opening of a transverse aqueduct should lie between the two, it is evident that this aqueduct will be opened or closed automatically by very slight oscillations of the pool above or below a given level.

Such is the principle of the self-regulating twin wickets. I will now show two applications of this principle, which will make it more readily understood.

The first is due to M. Carro, and the second I easily deduced.

The transverse aqueduct, which is to be opened or shut in accordance with the oscillations of the upper level, may have different functions.

For example, it may form the head of the supply-conduit, which leads the motive-water to the movable members of a dam. Examples of this will be found in the following chapters. [Already given.]

In this case the water ought to enter the transverse aqueduct whenever the upper pool falls below a given level. The lower wicket ought then to be shut, and the upper wicket to be on the swing, when the water is low.

It may also form the head of a waste-weir, designed to carry off in any direction the superfluous water from the upper pool. In this case the water should enter the transverse aqueduct when the upper level is raised above the normal level, and in consequence the lower wicket is the one to be closed, and the upper wicket to be opened during high water.

There are therefore two distinct methods of combination, according to which one of these two ends is to be attained.

I will begin by examining the first case, that in which the transverse aqueduct of the pier, or the abutment, conducts the water which works a movable dam.

Plate 14, Figs. 77 and 78, shows the arrangement invented by M. Carro, and the following is his way of explaining the automatic movements of the wickets :

Suppose a wicket, A B, (Plate 13, Fig. 75,) standing vertically against a sill on its lower side, and able to turn around an axis of rotation, I, in such a way that its chase falls in the direction of the current. The pressure which it supports under a fall, A P, is represented by the surface of the polygon, A B C D, and the center of pressure by the projection upon the wicket of the center of gravity of this polygon. In low-water the center of pressure is below the axis of rotation, and the wicket remains upright. If a flood comes, the center of gravity of the figure representing the pressure rises with the flood, and when it has passed the level of the axis of rotation the wicket swings.

On the other hand, let us consider (Plate 13, Fig. 76) a wicket resting against a sill placed on the upper side of its breach in such a way that it can only turn in the opposite direction to the preceding; the opposite conditions will prevail, opening during low-water, and closing during rises.

Then let us suppose that these wickets are united by a connecting-rod of such a length that the vertical position of one corresponds to the horizontal position of the other. During the period of low-water the lower wicket is naturally closed, and it keeps the upper one open. The motive-water then enters the transverse aqueduct, and assures the working of the movable parts that make a dam.

The river still rising, the center of pressure rises above the axis of rotation of the lower wicket and makes it swing, and its movement compels the closing of the upper wicket. The transverse aqueduct then no longer receives the water from above, and the movable parts, deprived of their motor, fall down on the sole. If the river subsequently falls, the center of pressure of the upper wicket descends below the axis of rotation, and by compelling it to swing, and in consequence to close the lower wicket, the motive-water is again sent to the dam, and the latter rises.

It is possible so to arrange the axes of rotation of the two wickets that the centers of pressure will coincide with them when the natural level of the river rises to a given height; for example, when this level below the dam reaches the minimum depth for navigation. The discharge of the river, corresponding to this minimum level, is known; from it is deduced the depth of the overflow, and consequently the level above which answers to this discharge when the dam is up. The shape of the polygon representing the pressure is then determined, and it is only necessary to find its center of gravity to know the height of the axes of rotation of the wickets.

At a slightly higher level in the upper pool the lower wicket will swing, and will set up the upper wicket, and, in consequence, the flow of the motive-water will be stopped.

At a slightly lower level in the upper pool the upper wicket will swing, setting up the lower wicket, and sending the motive-water through the transverse aqueduct.

The automatic working of the dam is then assured by means of the twin wickets.

M. Carro expresses the opinion that the opening of the wickets would not take place suddenly, so as to cause the river to pass too rapidly from one state to another more or less different. He says that the transition will undoubtedly take place by scarcely perceptible degrees, corresponding to a partial working of the wickets, and giving, in the transverse aqueduct, the effect of a level intermediate between those above and below. It can readily be understood that when the upper wicket is partly set up, its center of pressure will soon fall below its axis of rotation; it will then react against the pull of the lower wicket, and will hinder the latter from swinging completely, holding it at an inclination corresponding to its own.

In certain circumstances it might be useful to maneuver the wickets without waiting for their spontaneous movement. This can be done by fastening to the lower part of the lower wicket (Plate 14, Fig. 77) a chain which is wound around a drum. A second chain is likewise fastened to the lower end of the upper wicket and wound on the same drum, but in a contrary direction to the first chain, so that one unwinds as the other winds. The wickets may then be held wherever desired by simply turning the drum.

Fig. 79. Plate 14, represents the arrangement of twin wickets which may be used to carry off the surplus of a pool. The explanations already given, and an inspection of the figure, are enough to indicate how this pool will regulate itself spontaneously. The transverse aqueduct either empties the surplus into the lower pool, or into ditches for use in agriculture or in manufacturing.

Twin wickets cannot be used to form a dam in the bed of a navigable river, since they cannot get out of the way at any given moment, but we see that they can render services similar to those obtained from oscillating wickets.

DAMS WITH SHUTTERS WORKED BY HYDRAULIC JACKS—GIRARD SYSTEM.

I explained in Chapter VII that Thénard shutters, having their axes of rotation on the sole, present so great a resistance to raising as to be inapplicable to high lifts as long as only the ordinary mechanism of movable dams is used.

M. Girard, a civil engineer, who died in 1871, has found an easy method of working these shutters by pushing them by means of hydraulic jacks, which, at will, by means of a cock, may be put in communication with an accumulator on the bank.

This is the general idea of the system, whose trial was authorized by an official order of June 23, 1870. The point selected was on the Yonne, at the weir of the Ile-Brulée Dam, which is situated a little more than a mile below Auxerre, and has a normal fall of 6 feet.

The following is the description of the movable parts, taken from M. Girard's project for a high dam: (Plate 14.)

Each shutter is composed of three pieces of wrought iron of this shape, I, fastened

at bottom to an axle which forms a hinge throughout its length. This hinge turns in a cast-iron hollow quoin, made fast to the sole.

The I-irons are covered on their down-stream faces by a plate of sheet-iron, and on their up-stream faces by oak timbers.

A shutter is $11\frac{1}{4}$ feet in length, measured in a plane normal to the axis of rotation, and commencing at this axis. Its vertical projection, when it is up, is $10\frac{1}{4}$ feet; its horizontal width is 13 feet $1\frac{1}{4}$ inches.

A shutter, when up, has a batter of four-tenths. The space between two consecutive shutters is $\frac{1}{2}$ inches.

Below each shutter a cast-iron cylinder is fastened to the sole on a slope of about 10° ; this cylinder, called by M. Girard *corps de presse*, receives a piston, one foot in diameter, on whose outer end is a cast-iron cross-head, which is constrained to slide in three cast-iron guides, designed to secure its rectilinear motion. These guides are fastened to the sole, and are parallel to the prolongation of the axis of the cylinder of the jack.

Upon the cross-head of the piston are fastened three bars, which act as props to the shutter; each of these bars is fastened by a wrought-iron fork to one of the T-irons of the shutter at its middle.

Each cylinder receives at its lower end a gas-pipe of one inch interior diameter, whose other end terminates in the accumulator.

A three-channel cock, placed near the latter, permits either the introduction of water from the accumulator into the cylinder of the jack, or the removal of the water in the cylinder, or the establishment of a direct communication between the cylinder and the pump which supplies the accumulator.

Each shutter having its own jack, supply-tube, and regulating-cock, can at will be worked by itself, or in conjunction with the others.

The motive-water is obtained either from the upper pool or from a tank, by means of a double-acting pump set in motion by a turbine, which receives its impulse from the fall at the dam.

The turbine, the tank, the force-pump, and the accumulator are placed in a little building constructed on the abutment of the weir.

The use of a turbine presupposes the existence of a fall.

At the Ile-Brulée Dam, as the weir is not shut until after the navigable pass, which is provided with Chanoine wickets, is closed, the reduction of section which results from the closing necessarily produces a difference of level between the water above the dam and that below it.

It is only necessary that this difference of level should be sufficient to enable the turbine to do its necessary work. I will take up this matter directly.

In case there is no fall, as if, for example, all the dam were provided with Girard shuttles, and the sill were not raised above the bottom, it would be necessary to resort to a steam-engine to work the supply-pump. Such was M. Girard's first idea, but having observed that at the Ile-Brulée Dam the preliminary closing of the pass would cause a fall of at least 16 inches, the turbine was calculated so as to produce with this fall the useful work necessary for raising the shutters, and in this first application of the system the idea of a steam-engine was abandoned.

As the pump can act directly on the cylinders of the hydraulic jacks, the accumulator is not indispensable, but it is useful, in that it serves to equalize the work of the pump, and also in that it permits more prompt maneuvering, as there is always pressure in reserve even before the closing of the pass is begun.

This description is sufficient to explain the method of opening or of closing the weir, a maneuver which is reduced to turning to a certain point each one of the cocks of the supply-pipes.

Any shutter whatever may be stopped at any moment whatever in its rise or fall by a simple turn of the corresponding cock.

I have already pointed out the advantages resulting from this, both in moderating the scouring force of the cataract and in providing for a small rise, precisely the outlet which it needs, without sensibly changing the upper level.

It is important that the piston of each jack should be prevented from acquiring too great a velocity, even though there may be a great excess of power. This result is obtained by giving the cock an opening of such a size that the water in passing through it loses a part of its living force.

Suppose, for example, that the piston has a velocity of 4 inches per second, a velocity which cannot cause an injurious shock when it is stopped; suppose, besides, that the pressure in the accumulator is of twenty atmospheres, the velocity of exit of the water will be $\sqrt{2g \times 20 \times 34} = 209$ feet; and all that is necessary in order that the piston speed may not exceed 4 inches per second is that its section should bear the relation to the

opening in the cock of $\frac{209}{0.33} = 627$.

With this speed the travel of the piston is 5 feet, and the raising or lowering of the

whole weir will take place in 15 seconds. Making due allowance for losses of pressure, we can still feel sure that each complete maneuver will take place in less than a minute, whatever be the length dammed.

The cocks can readily be turned by a float, and consequently they can at will be passive or automatic.

The system which has just been described has several remarkable properties, namely: Rapid and easy maneuvers without shock.

Great reduction in leakage, on account of the less number of spaces between shutters.

Possibility of application to great lifts and lengths.

But there are also inconveniences.

The principal objection to the system arises from the effect of freezing on the supply-pipes, and on the cylinders of the jacks.

If we endeavor to avoid these effects, by placing the machines at a considerable depth below low water, it becomes very difficult to repair them. Besides, the smallest leakage in apparatus, which is almost constantly subject to heavy pressure, will stop its workings.

M. Girard proposed filling the pipes and the cylinders with a mixture of water and alcohol, which only freezes at a very low temperature. This water was to be collected in a waste-well when it came out of the cylinders, when the dam was lowered, and then repumped into the accumulator; but this expedient did not appear practical, and it was considered sufficient, at the Isle-Brulée weir, to place the communicating pipes 5 feet below the lowest water, after the whole apparatus had been subjected to a proof-pressure of at least thirty atmospheres.

The pipes are placed in a masonry conduit prepared in the sole, and covered by a cast-iron plate.

To repair, while under pressure, a shutter which no longer works, a screen would probably be placed in front of this shutter, which would support itself on the neighboring shutters; the one to be repaired, being thus relieved, might be removed; but unfastening under water and replacing the cylinder and its pipe are rather delicate operations, and are very rarely admissible. Use will teach whether this is too great a difficulty in practice.

The absolute rigidity of each shutter has also been made an objection to this system. If a floating body strikes, it will not yield, and violent strains are produced both on the fastenings and on the organs themselves; as a matter of fact, there is the same trouble with a needle-dam.

On the other hand, I have seen a raft of timber drift against the navigable pass of the Evry dam, and break through, making the wickets swing, but causing no damage.

In addition, there is reason to fear that sand may work in between the slides and the cross-head of each piston, and may give rise to so much friction as to cause too great wear on the rubbing surfaces.

Lastly, when the operation of raising is begun, the prop makes a very acute angle with the shutter, and consequently the normal component, which alone performs useful work, is at first only a feeble fraction of the force exerted on the piston. It also follows that the component in the direction of the shutter is large, and produces friction and compression on the axle and its collars, which cannot be neglected.

The author's calculations on the moments of the developed forces are omitted.

* The dimensions of the force-pump, which in case of need must act directly on the hydraulic jacks, without the use of the accumulator, depend on the time allowed for raising.

If we suppose, for example, that the weir should be raised in the space of ten minutes, and if the travel of each piston is 5 feet 7 inches, the volume generated is 4.24 cubic feet, and for the seven shutters 29½ cubic feet. This is equivalent to a continuous discharge of 2.97 cubic feet per minute. The pump and the turbine which puts it in motion under a known fall of 16 inches, for example, as at the Ile-Brulée Dam, should be so arranged as to produce this discharge of 2.97 cubic feet per minute under the pressure which corresponds to the fall of 16 inches.

In addition, it is necessary that, after the fall increases, the pump and the turbine should still be able to produce this same discharge under the increased pressure which will result.

As I have said before, the navigable pass of the Ile-Brulée Dam is provided with Chanoine wickets. Its weir only is provided with Girard shutters, whose dimensions are smaller than those represented on Plate 15, but whose general arrangement is the same.

Each shutter is 11½ feet wide and 6½ feet long, measured along its slope and in a plane normal to the axis of rotation. The total batter of a shutter when up is 16 inches, which corresponds to an angle with the vertical of nearly 12°.

The weir is 82 feet long and has seven shutters, each interval being 1½ inches.

Two of these seven shutters have Papillon valves in their chases.

The upper pool is at the reference 314.72 above the sea; the lower pool is at the reference 308.65; whence results a fall of 6.07 feet.

The crown of the masonry which forms the permanent part is at the reference 303.15; that is, at half a foot below the level of the lower pool. The axis of rotation fastened on this crown is at 3 inches below the level of the lower pool.

A shutter, with all the iron-work, weighs 2,552 pounds.

A piston, with its cross-head, weighs 3,938 pounds.

It is conceded that the pressure in the reservoir should not exceed 25 atmospheres.

The administration, contrary to its general practice, contracted with the inventor, M. Girard, for the shutters of the Ile-Brulée weir.

The sum allowed for furnishing and setting the movable apparatus and the dependent mechanisms was 44,000 francs, (\$8,360.) This would be 537 francs (\$102) per running foot.

¶ In concluding this description it should be stated that M. Cambuzat, in his report on the navigation of the Yonne and the Upper Seine, from which we have already quoted freely, states, in regard to the Girard shutters, that they work well, but that they are costly, and that a needle-dam is preferable.

As we here end our quotations from foreign reports, it is proper to state that all the measures and calculations which have been quoted from the French are given in the originals in terms of the French metrical system. They have all been transformed into English measures, as it was believed that the usefulness of this report would have been seriously impaired if a unit of measure had been used which did not immediately convey definite ideas of dimension to American engineers.

SUMMARY AND CONCLUSIONS OF THE BOARD.

We have thus far given drawings and descriptions of all the methods of which we could learn that have been used up to the present time for the management of hydraulic gates or movable dams. The most serious difficulty in applying any of these systems to the Ohio River arises from the severity of our winters and the great masses of ice that must be provided for. In order to permit these heavy masses to pass freely, it is indispensable that in the plan adopted there should be no projecting mechanism that could possibly be injured when the pass is open; in other words, the sides and bottom of the pass should then be as smooth as those of an open cut. An approximation to this condition is an absolute necessity.

Leaving temporarily out of consideration the question of the lengths or heights of passes and weirs, we will first discuss the subject of apparatus.

The following are the methods thus far described:

1. "The bear-trap," Plate 1, Figs. 1, 2, 3.
2. The wicket used on the Riom, Plate 1, Figs. 4, 5, 6, 7.
3. Thénard shutters, Plate 1, Figs. 8, 9, 10, 11, 12.
4. Thénard shutters, as modified by Fouracres, Plate 4, Figs. 30, 31, 32, 33.
5. Poirée needle-dam, Plate 2, Figs. 13, 14, 15, 16, 17, 18.
6. Combination of Poirée dam and Thénard shutters, Plate 3, Figs. 25, 26, 27, 28, 29.
7. Chauoine wickets, Plates 5, 6, 7, Figs. 37, 38, 39, 40, 41, 42, 43, 44, 45.
8. Desfontaines wickets, Plates 8, 9, Figs. 46, 47, 48, 49, 50, 51.
9. Modified Poirée needle-dam, Plate 10, Figs. 54, 55, 56, 57, 58.
10. Cuvinot drum-wickets, Plate 11, Figs. 63, 64, 65, 66.
11. Krantz wickets with ponton, Plate 12, Figs. 67, 68, 69, 70.
12. Carro gates—improved "bear-trap"—Plate 13, Figs. 71, 72, 73.
13. Girard shutters, Plate 15, Figs. 80, 81, 82, 83, 84, 85, 86.

The objections to the "bear-trap" gates have been given at length by M. De Lagrené, and need not be repeated here. The fact that this system has been in use in France for many years to provide artificial

waves for lumbering, and yet has not been adopted on the larger rivers, is sufficient to condemn it. If such a combination were used at all, it would probably take the form of the Carro modification, and therefore we need not spend time on the prototype.

Mr. H. Werner, C. E., proposed a number of "bear-trap" gates of ordinary width, giving each pair separate inlet and outlet pipes. As these gates were to be raised in succession, it was necessary to retain the water under each pair by closing each end of the space under them. For this purpose he designed solid frames of triangular shape, which were to be lifted by the main gates, rising at right angles to them, and closing each end of the space under them. The joints between the upper main gates were to be closed by narrow aprons, resting on and raised by them.

This method of construction was tested on a large model, but did not give satisfactory results. There was no trouble in raising the gates, but they could not be lowered except by hand. The difficulty seemed to arise from the side gates refusing to fall after the water was let out. The friction between them and the main gates was such as to hold them fast. This might have been expected, since even in the ordinary "bear-trap" there is difficulty in lowering the gates unless the angle between them is very obtuse.

The second method, that in use on the Riom, is manifestly only designed for small lifts and for rivers not incumbered by ice or drift. It is evidently so much inferior to some of the others that no time need be spent in discussing it.

The third, fourth, and sixth methods, two of which differ only in minor details, the third being a combination of the shutter with another system, may be discussed together. The great difficulty of raising high Thénard shutters has been mentioned in the previous discussions, and besides this, the first two methods, or the Thénard shutters proper, seem to be very objectionable in a river which carries much ice or drift. The third method, which uses but one shutter, and has a Poirée dam in addition, seems to have a superfluity of apparatus. The only apparent reason for the combination is to secure rapidity of opening by using the dam as a screen behind which to raise the shutters, and subsequently, after the dam has been removed, to drop the shutters by a tripping-rod. In view of the various devices already described for promptly opening a needle-dam, it seems unnecessary to have anything else where it is used, and therefore we are of the opinion that all the methods using the ordinary Thénard shutters should be rejected.

Of the systems that are left for examination, those of Poirée and Chanoine are in very general use. Desfontaines drum-wickets seem to be used only on weirs in the Marne. Girard shutters are used on the weir of a single dam on the Yonne; the Krantz system is in process of trial; and the Cuvinot and Carro systems exist only on paper.

The first question to be settled is the general arrangement of the locks and dams that should be recommended for use on the Ohio. The French system has a pass whose sole is level with the natural bottom of the river, and a weir whose permanent part is somewhat higher. When the pass is open, and the weir-wickets are down, the river is almost in its natural condition, but there will be an increase of velocity through the pass over the velocity that existed before the construction of the dam, the amount of which will depend upon the height and arrangement of the weir. The system which the board had in view was to build ordinary slack-water dams, and to make openings in these, connected with an inclined plane below, so that coal-fleets could be passed

through the openings and down the inclined pass into the lower pool. This system was naturally suggested by the existing slack-water system on the Monongahela.

Comparing it with the French systems, assuming equal lifts at the dams, we find that the difference is that, on our plan, the weir is permanent up to the level of the pool, and the sole of the navigation-pass is about half way between the low-water line and the surface of the pool. Both weir and pass are therefore higher than is the practice in France.

Assuming, for the present, that the general combination indicated is an advantageous one, we will give a description of the various styles of gates that were examined, and, after describing the one which in our judgment seemed most suitable, will resume the comparison with the French methods.

Assuming a dam with a lift in low-water of 8 feet, as is the case with the lower dams on the Monongahela, we proposed to cut down a portion of this for a width of 200 feet, more or less, and a depth of 4 feet, and to provide the passage thus made with easily-worked apparatus for opening and closing at will. We also proposed constructing below this cut an inclined plane of slight declivity, which would form a pass into the lower pool. It should be stated that when we commenced investigating this subject we were ignorant of the great progress that had been made in it by modern French engineers, as almost the only record of their work is the *Annales des Ponts et Chaussées*, a publication which is seldom to be found in American libraries. The copies from which the translations were made were borrowed from the library of the Headquarters of the Corps of Engineers. M. De Lagrené's work is just published, and was only received during the present month.

The following plans were especially examined by the board, the majority of them being tested by models:

Mr. S. Petittidier, C. E., proposed the system shown in section and elevation in Plate 16, Fig. 87. It consisted of a solid dam of wood, three feet wide and six feet deep, thoroughly bolted and stiffened with iron, which moved up and down, in a narrow chamber with vertical sides, under the action of heavy counter-weights at each extremity. Friction-rollers on each side of the vertical chamber facilitated the movement. The counter-weights were hung at such a height that when the water rose they were partly submerged, and their loss of weight caused the dam to descend into the chamber, and to gradually open the pass. The counter-weights were protected from floods by heavy crib-work, and automatic signals were designed to indicate, both by day and night, whether the pass was entirely or only partly open. The designer claimed that this system would work automatically. The model did not sustain his views, on account of the friction of all the parts, and the whole system was open to the objection that it would only work in floods, and could not be maneuvered without complicated mechanism and a considerable expenditure of work, at a time when there might be water enough to let fleets through, and yet not sufficient to permit the pass to remain open for any length of time.

Captain J. A. Wood, of Pittsburgh, suggested a modification of the "bear-trap." He proposed to hinge the two gates together at top, and to maneuver them by chains wound around an axle under the gates, to which motion should be given by steam or water power. The upper gate turned on an axle fastened to the floor of the pass, and the axis of the lower gate was fastened to an apron at its foot, which could move horizontally in grooves on the platform of the pass. This apron was so

fastened to the platform that it could not rise. By drawing it up-stream it caused the gates to rise, and they were lowered by reversing the motion until the two gates were laid down on the platform, and the passage was left open. The gates could not be lowered into a horizontal position, as in that case it would be impossible to raise them, since any force applied to the apron would be directly transmitted to the axis of the upper gate.

No arrangement was made for admitting water under the gates, and consequently the motive-power had to lift the entire body of water resting on the gates. On this account the greatest power would be needed at the commencement of maneuvering, but at this time the lever-arm of the force would be least, and it would be acting at the greatest disadvantage. For these reasons the board did not deem it necessary to experiment on Captain Wood's system, but contented themselves with an examination of his model.

There is a remarkable similarity between the gates of Captain Wood and those designed by M. Carro. In both cases the twin gates are hinged to each other, and in each case the lower end of the lower gate is kept down on an iron track. Captain Wood, however, uses no links, and entirely overlooks the advantage of utilizing the natural water-pressure to lift his gates. On this account he would require such enormous extraneous force that his system would be impracticable for any considerable width of opening.

The Hon. F. R. Brunot, of Pittsburgh, exhibited to the board a small model of a floating hydraulic gate, which seems to meet the requirements of the case. Mr. Brunot only presented the model, leaving the completion of the details necessary to put it in practice to be elaborated by us. His system is shown, in section, on Plate 17, Figs. 90, 91, 92. It consists substantially of a hollow caisson or ponton of the length of the desired opening, (see Fig. 92,) and of suitable width and depth. A chamber is excavated in the dam at the place chosen for the gate, and when the latter is in place and lowered, the top of the caisson is even with the floor of the pass, and the passage is free. The up-stream edge of the top of the gate is securely hinged to the up-stream edge of the gate-chamber.

Two methods of maneuvering the gate were proposed by the inventor. The first method was to make a connection between the chamber and the pool above the dam, so that the hydrostatic pressure of the upper level might raise the gate. It could only rise in an inclined position, as the upper edge would be held down by the hinges. To lower the gate the connection with the upper pool would be closed and that with the lower one opened, and the gate would fall on the removal of the water-pressure. The service of the gate would be simple and inexpensive, as one man only would be required, and his work would be limited to opening and closing valves. One objection to this method of working is that a certain amount of play is necessary between the gate and the lower side of the chamber in order to prevent danger from jamming. The width of this opening could hardly be less than 2 inches, and this width into the length of the opening (200 feet) would give a total opening of $33\frac{1}{2}$ square feet. In order, therefore, to retain within the chamber the pressure of the upper pool, it would be necessary to have a channel of communication with it of a greater sectional area than $33\frac{1}{2}$ square feet. As this pressure would have to be kept up during the season of low water, there would ensue such an expenditure of water that, in many localities, the gate could not be used. On the Mononga-

hela, where the first pass with hydraulic gate should be built, the flow during summer is often insufficient to supply the lockage.

Another objection to this method is that it will oftentimes be necessary to lower the gate and open the pass when the water in the lower pool is even with the top of the chamber. In this case our experiments indicated that the water pressure on top of the gate would not suffice to make it fall.

The other method suggested by Mr. Brunot is to fill the gate with water when the chute is to be opened, and to pump the water out when it is to be closed. This will, undoubtedly, secure the desired result beyond any possibility of failure, no matter what may be the difference of level between the two pools, and this is the method which we recommend. The power necessary to do the pumping can always be had from the fall at the dam, and a turbine-wheel in a well in the abutment would be the natural method of applying it.

There is a danger that sediment may enter the chamber of the Brunot gate through the opening left for play, and also that sticks and stones may get fast in it and interfere with the movement of the gate. For this reason, and in order to secure a tighter chamber, we thought that the system shown in section in Figs. 88 and 89, on Plate 16, would be better. In this the Brunot gate is hinged to the lower edge of the chamber, and a heavy wooden apron rests on it, which is hinged above the chamber to the platform of the chute. This system gives ample play to the gate, and almost entirely obviates any trouble from sediment and from floating bodies or stones rolled along by the current. It is, in fact, a combination of the Brunot and the "bear-trap" systems. There is also a very striking similarity to the main part of the Krantz system, the chief difference being in the method of fastening the apron. It is an apparent objection to the Krantz system that the cavity prepared for the lower end of the apron might be filled with sediment or obstructed by stones and gravel rolled along the bed of the stream. We finally, however, concluded to abandon this combination, because we found that by putting a shoulder on the lower edge of the Brunot gate, as shown in Figs. 90 and 91, we could retain sufficient play, and yet make a tight fit against the chamber-wall, and because in elaborating the details of filling and opening the gate in the combined system, we found many practical difficulties that do not exist in the Brunot system proper. In the combination of the two systems the apron would have to be very wide, for the same reason as in the "bear-trap" proper, and it would be open to the same objections.

Col. P. J. Schopp, C. E., suggested what he termed a "triangular caisson dam," but as it consisted substantially of a number of Brunot caissons of triangular cross-section, each provided with an independent chamber, and maneuvered in succession, we did not deem it necessary to test the plan in a model. He proposed working his gates entirely by changing the pressure of the water under them, but, as we have previously stated, our experiments on models indicated that this method would sometimes fail, and the application of the pumping system to a number of caissons would increase the difficulties of working, without corresponding advantages.

The system now in use on the Yonne and Seine has the advantage of being the gradual growth of long years of study and experiment, and will, undoubtedly, at least on the Upper Ohio, radically improve the navigation. The question before us, therefore, is whether this system is the best that can be devised for such navigation as is used on the

Ohio River, or whether we cannot obtain a method more suited to our wants.

As can be seen from the discussion, and from the tables which have been given, the French system gives 5 feet in depth at the head of each pool, and the lifts, or differences of level between the pools, vary on the Seine from 4 feet 5 inches, at the Melun Dam, to 9 feet 10 inches at Port-à-l'Anglais. The latter lift is exceptionally great, on account of the wish to avoid constructing a dam within the limits of Paris, the next greatest lift being 6 feet 1 inch, at Ablon.

At the La Madeleine Dam, which may be taken as a sample, the tops of the wickets of the pass, when up, are 8 inches lower than those of the wickets of the weir, and they are 4 inches below the surface of the upper pool. Four inches is therefore the minimum depth of water that is expected to pour over the tops of the wickets of the pass. During this stage the water of the pool below stands against the back of the pass-wickets, at a vertical height of 4 feet 4 inches. Should the water get too low to give four inches over the tops of the pass-wickets, the dam can be tightened by temporarily covering the spaces left between the wickets.

The length of the shortest pool on the Upper Seine is 3.38 miles and that of the longest seven miles. The fall of the river between the Varennes and the La Cave Dams, a distance of 18.63 miles, is 23 feet, or an average of about 15 inches per mile, while between the same dam and that at Port-à-l'Anglais, a distance of 56 miles, the fall is 60 feet, which is an average of about 13 inches to the mile. The average fall of the Ohio in the first twenty miles of its course is 17 inches per mile, but this slope rapidly changes, and in the first fifty-six miles the fall is 53.3 feet, or at the rate of about 11½ inches per mile. The slopes of the two rivers, in the portions compared, are thus seen to be nearly the same, though the greatest floods in the Ohio, in the sections compared, vary from 35 to 45 feet, while in the Upper Seine they only vary from 16 to 23 feet. As might be expected from the greater height of floods, the banks of the Ohio are much higher above low-water than those of the Seine, and therefore higher dams can be built without greater danger of overflow.

One objection to all the French systems is that the mechanism consists of a great number of parts, all of which must be kept in perfect working order, a thing which is less difficult in France than in the former country because there is a long-established and well-organized and trained body of inspectors, engineers, lock and dam tenders, and assistants, whose lives are devoted to such work, and who are thoroughly capable of attending to it. The lack of such a body in the United States makes it eminently desirable that all machinery should be of the simplest possible kind, and we believe that the plan which we recommend has at least this merit.

Another and more serious objection to the French systems comes from the greater cold of our climate, and the greater danger of injury by ice. The account already given shows that the Seine dams were greatly endangered by an unusual cold of 21°. As this is a very common temperature with us, and as the thermometer is not unfrequently below zero, it is manifest that the danger mentioned would be both more frequently encountered in this country, and more dangerous when encountered, particularly in view of the higher and more sudden floods, and the greater masses of drift-wood. Therefore, with our present information, we think it would be better to test the Brunot gate in preference to adopting the French systems thus far in use. If the test is unsatisfactory, we still have them to fall back on, while if it is a success we be-

lieve that we will have a simpler, stronger, and more readily handled apparatus.

Should the system which we recommend for trial be adopted, we will find ourselves provided with a navigation that differs in many particulars from that used in France. In the latter country, as soon as the natural depth in the river is less than 5 feet, the passes are closed, and all navigation in either direction is carried on through the locks. On our system, if we can get a gate, as we think we can, that can be opened in two minutes, and closed in five, it will be quite practicable to keep up an intermittent down-stream navigation through the pass throughout almost the whole year, as the opening of the gate for not to exceed ten minutes at a time, (which, allowing for diminished discharge while being opened and shut, will make the total expenditure of water about equal to a full opening of the chute for 5 minutes,) will probably not injuriously lower the level of the upper pool. We would thus have a natural down-stream navigation throughout almost the entire year, which would be an immense advantage, since our heavy products, such as coal and manufactured iron, all go down the river. To counterbalance this advantage, we would have the disadvantage of forcing all up stream navigation, except in very high water, to pass through the locks. The latter would have to be higher than the French locks, and our expenditures for masonry and timber for the dam, and inclined plane, would much exceed theirs. To counterbalance this, we have simpler constructions, less complicated mechanism, (which is both very costly, and must be carefully watched and kept in order,) and probably less expense for attendance. It is, therefore, mainly on account of the special character of our climate and of our navigation, that we recommend that a system differing from those used in France be first tested, in preference to copying what are successful in their native country, but which might not work so well here. We wish it to be specially understood, that while we have attempted to collect all available information on this subject, we do not presume to decide the question now, but limit ourselves to recommending a preliminary experiment. Having, therefore, decided in favor of an experiment upon the plan proposed by Mr. Brunot, it now remains to elaborate its details.

There are two methods of filling the gate—by opening valves in the top of the gate itself, or by opening a pipe which communicates with the interior of the gate. As the gate rises and falls around a horizontal axis, there is some difficulty in devising an apparatus to move these valves at all times which shall itself be sheltered from floating bodies. Moreover, valves in the top of the gate are liable to injury, and they weaken the gate where it ought to be strongest. For these reasons we propose to permit water to enter by a pipe under the platform of the chute, which shall connect with the interior of the gate by several branches of flexible pipe entering just below the hinges. The main pipe will be controlled by a valve worked from the abutment, as shown in Fig. 92. It is calculated that a two-foot pipe will fill the experimental gate, 100 feet in length, in 2 minutes, which is, probably, quick enough. To empty the gate a centrifugal pump is used whose suction-pipe has a flexible length to connect it with a pipe extending to the bottom of the gate. This pump will be set in motion by a turbine wheel. The necessary power to drive this pump was calculated by assuming 5 minutes as the time for the work, and taking the capacity of the experimental gate as 5,000 cubic feet, and the lift as 6 feet. We, therefore, have a quantity of work of 375,000 foot-pounds per minute, or 11.4 horse-power. The effective work of pumps is given by Bourne as ranging from 30 to

65 per cent. of the power applied to them, and, therefore, with an assumed efficiency of 38 per cent. we find that we require 30 horse-power to work this pump.

To get the size of turbine necessary to develop this effective power, we use Francis's formula :

$$D = 4.85 \sqrt{\frac{P}{h \sqrt{h}}}$$

in which $P = 30$, the effective horse-power, and

$h = 6$, the assumed head of water. We, therefore, find—
 $D = 6.93$ feet.

The amount of water necessary to supply this wheel is found by the formula, also given by Mr. Francis :

$$Q = 0.5 D^2 \sqrt{h}$$

Whence we find—

$$Q = 58.8 \text{ feet per second.}$$

To supply this amount of water without great velocity, and, therefore, without sensible loss of head, the water in the channel leading to the turbine should have a velocity of not more than 3 feet per second ; and, therefore, the cross-section of the channel should be about 20 square feet. We have, therefore, taken a width of 4 feet and a depth of 5. The positions of the pump and turbine are shown in Fig. 92.

It is important to have some arrangement for the automatic filling of the gate, should a sudden flood come in the night, or when the gate-tender was absent or negligent. This is provided for by a stationary pipe at the far end of the gate, which is sheltered from floating bodies by the recess at the end of the chamber. The height of this pipe is such that when there is a greater depth in the chute than seven feet, the water overflows into the gate. This pipe also answers as an air-pipe during the maneuvering of the gate.

The most important navigation on the upper part of the Ohio River is the transport of coal, and as this transport is always down stream, and as the ponderous coal-fleets are not easily checked or stopped, it is very desirable that the process of lowering the gate and opening the pass should be very expeditious, while there need be no great hurry in raising the gate. The system proposed answers these ends perfectly. One man can maneuver the gate, and it can be filled with any desired rapidity. If the 2-foot pipe should not do the work fast enough, there is no difficulty whatever in using one of greater diameter. After the fleet has passed, the attendant has only to open the gate of the turbine, and in a few minutes the pass is closed. It seems hardly possible to devise a system that could promise better results.

In order to scour out any sediment that may accumulate in the chamber, a culvert is made at the far end, and inlet pipes at the abutment. As this operation would seldom be necessary, (possibly once a year,) it is believed that the management of the valve at the far end would offer no practical difficulty. Excepting this one valve, all the mechanism is on the abutment, and is therefore always accessible.

Besides the gate, the shape and details of the pass require special attention. In order to acquire knowledge in the working of passes, or chutes, as they are frequently called, the board went to Lock Haven, in Pennsylvania, and examined the chute in the dam across the Susquehanna at that place. This chute and dam are shown in Fig. 36, plate 4. The length of the chute is 1,295 feet, and its width is 31 feet. The differ-

ence of level, in low water, between the pool and the river below, is 11 feet, and the slope of the chute is 1 in 142.

There is no gate at its head, as it is left open until the water above becomes too low, and then a temporary dam of plank, resting against a horizontal beam, is constructed. The chute was unfortunately closed when we visited it, but we obtained much information about it from an ex-officer of engineers, Mr. R. W. Petrikin, residing in Lock Haven. We learned that it was only used in running rafts down the river, and that there was a marked wave at its entrance, and also that rafts in passing out of the chute into the river were generally submerged. At the Williamsport chute, on the same river, rafts dive so much that in order to diminish this tendency they are forced to use, at the lower end of the chute, floating timbers with one end fastened to the bottom. Neither the wave at the head of these chutes nor the diving at the foot is injurious to rafts, but they would be to coal-fleets. A very important matter of detail is to make as much friction as possible on the bottom and sides of the chute, so as to retard the velocity of the water. The superiority of the Lock Haven chute to the others on the Susquehanna is attributed, in some measure, to the fact that it has a stone bottom, while others have wood. The stone paving has become so rough that it checks the current very appreciably.

The board believe that by a judicious widening of the head of the chute, so as to cause a large body of water to enter, the head-wave can be almost if not entirely obviated, and that a similar widening at the foot would probably work equally well there. But these and other details can only be settled by actual trial, and without such trial they would be unwilling to recommend the system for use on the Ohio. If it is a success, there need no longer be any difference of opinion about the radical improvement of that river. As such vast interests depend upon this trial, they would most urgently press its importance upon Congress.

To test the whole scheme, the Monongahela Navigation Company, who need something of the kind for their own use, offer the use of the lowest dam on the Monongahela for a chute 100 feet in width, or half the width proposed for ultimate adoption on the Ohio. The two locks in their dam No. 1 are insufficient to transact the rush of business that crowds upon them whenever there is a coal-boat rise in the Ohio, and many coal-barges lose an opportunity of getting to market on account of the impossibility of getting through the locks in time. If the chute proves a success, barges can safely lie in pool No. 1 until a rise comes, and then pass down the river promptly. An indirect result would be to add pool No. 1 to the harbor of Pittsburgh, which is now greatly overcrowded.

The Monongahela Navigation Company is, therefore, equally interested with the United States in finding a successful solution to the problem before us.

They therefore, through their president, Hon. J. K. Moorhead, offer for this purpose their dam No. 1, and agree to pay one-half the cost of the experiment, it being understood that in case of success they are to become the owners of the gate and chute.

This proposition seems to us a fair one to both parties, and we would therefore recommend its acceptance. According to the most careful estimate that we have been able to make, the cost of putting in a chute 100 feet wide, with a movable hydraulic gate, the bottom of the chute being 4 feet below the crest of the dam, will be \$80,000. We would therefore urgently recommend the appropriation, by Congress, of \$40,000 for the purpose of experimenting with a navigable chute, to be opened

and closed by a hydraulic gate, in one of the dams of the Monongahela Navigation Company, provided that the chute and gate be constructed in accordance with the plans of the United States engineer in charge of the improvement of the Ohio River, and provided, also, that the Monongahela Navigation Company shall pay one-half the actual cost of construction, without any charge for the use of their dam or of such tools or working-machinery as they may have on hand. It should also be agreed that, in consideration of the foregoing provisions, the chute and gate shall become the property of the said Navigation Company, but that both chute and gate shall be subject to such changes or modifications, at the joint expense of the United States and the Navigation Company, as may be directed by the United States engineer in charge, until in his opinion further change or experiment is unnecessary. It should further be agreed that in case the experiment should prove a failure, the United States shall be liable for no charges for the cost of removing said chute and gate, and restoring the dam to its original condition.

There are still many details to be elaborated in the practical construction of the Brunot gate which the pressing necessity for an early report, and the unexpected amount of time and labor required to collect the foregoing information, make it impossible for the board to complete. They believe, however, that they have sufficiently covered the subject in the foregoing, and would recommend that the duty of preparing the practical details of construction be assigned to the engineer in charge of the improvement of the Ohio River.

Respectfully submitted.

G. WEITZEL,
Major of Engineers, Brevet Major-General, U. S. A.
W. E. MERRILL,
Major of Engineers and Brevet Colonel.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

N 4.

IMPROVEMENT OF THE MONONGAHELA RIVER.

In my report of September 1, 1873, the progress of this work was given up to that date. This consisted in the purchase of land for the site of the proposed lock and dam at Hoard's Rocks, W. Va., and the letting of a contract for the construction of the lock.

Work was begun by the contractors in opening a quarry for stone in September last, and soon after the excavation for foundation was commenced. The progress of the work has thus far been slow, and I hardly think it probable that the contractors will be able to complete the lock this season, as contemplated by their contract. The excavation for the foundation is now complete, and a large quantity of stone of all classes is ready for the walls. From present appearances, not over five or six courses will be built by the close of the season. These, however, are the ones that are most troublesome and most subject to delay by rises in the river, and by land-slides. After they are finished, the work can progress smoothly and rapidly.

The funds appropriated for this work will probably be sufficient to complete the lock, and a small margin may be left toward building the dam. The additional sum of \$22,000 will, however, be necessary to

complete the improvement at Hoard's Rocks, being the difference between my estimate for the current year (\$47,000) and the amount (\$25,000) appropriated by act of June 23, 1874.

To complete the improvement of this river so as to properly connect with the slack-water system already established on the Lower Monongahela, will require two additional locks and dams, one of which should be built at or near Cheat River Ripple, and the other at Jacob's Creek.

In estimating for a lock at Cheat River Ripple, I only do so because a lock must be built at or near this place in order to carry out the system of improvement recommended by me and approved by Congress. The question as to who should build it is an open one, as this matter has never been settled; but presuming that my opinion would be desired, I give it herewith. I think that it would be better if the United States were to build this lock, although it is in the State of Pennsylvania. The Monongahela Navigation Company is bound by law to make a navigation to the State-line, but not beyond it. The Hoard's Rocks lock is beyond this line, and a good navigation cannot be made up to it without two more locks, or one, besides the one which the company must build. But should they comply with their obligation and build a lock with a lift of 16 feet, the one to be built by the United States need have only 4 feet of lift. The 16-foot lock would have a lift that experience has shown to be too great for useful service and the 4-foot lock would have an absurdly small lift. As a matter of law, I suppose that the navigation company could be compelled to build the lower 10-foot lock and pay a proportion of the cost of another lock of equal lift above. As a matter of expediency, however, I would recommend that the United States assume the entire cost, and, therefore, the undivided control of the lock at Cheat River Ripple, only requiring of the Navigation Company a relinquishment of all claim to control the navigation of that part of the Monongahela, and an agreement that the lock, which they must build, shall have 6 feet at low water over its own lower miter-sill, and shall raise the surface of the water 10 feet. Several of the locks on the present navigation have but 4 feet on their lower miter-sills in low water, but the Company is now engaged in raising its dams so as to give 6 feet, and my own calculations have all been based on a 6-foot navigation in the part of the river in the State of West Virginia.

If the United States should build the lock suggested it will require an appropriation of \$110,000; I therefore make a contingent estimate for this amount, presuming that all legal questions as to its construction will be settled with the navigation company by the proper authorities.

ESTIMATE.

Completion of dam at Hoard's Rocks.....	\$22,000
Dam at or near Cheat River Ripple, Pa.....	110,000
	132,000

A statement of the financial condition of this work at the close of the fiscal year is hereto annexed.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$90,000 00
Deduct amount expended in last fiscal year.....	409 14
Amount appropriated by act approved June 23, 1874.....	25,000 00
Amount expended during the fiscal year ending June 30, 1874.....	6,120 13
Amount available July 1, 1874, (\$108,470.73 — \$403.84).....	108,066 89
Amount required for the fiscal year ending June 30, 1876.....	132,000 00

N 5.

IMPROVEMENT OF THE GREAT KANAWHA RIVER.

Mr. A. M. Scott has been my assistant engineer in local charge of the Government work on this river.

The first appropriation for the improvement of this river was made for the fiscal year 1873-'74, and my last annual report contains a statement of the contracts made under that appropriation, and an account of the work done under it up to September 1, 1873. The present report will bring up the record to August 15, 1874, at which date, in obedience to your orders, the work was transferred to Maj. W. P. Craig-hill, Corps of Engineers.

The last annual report stated that contracts had been made for work at Cabin Creek Shoals, Elk Shoals, and Two-mile Shoal.

Cabin Creek Shoals.—Sixteen miles above Charleston, and seventy-three and a half miles above the mouth.

This contract was let soon after I took charge of the river, and before Mr. Scott, the superintendent, had an opportunity to acquire sufficient local knowledge of its peculiarities. It being important to get to work as speedily as possible, in order to utilize the low-water season, I told Mr. Scott to follow the advice of the Kanawha board, and make the best estimates that he could. The contractor for this work also got the contracts at Elk Shoal and Two-mile, and spent all his time on them. He died before he could begin at Cabin Creek, and his contracts passed into the hands of his executor. The latter asked to be released from the Cabin Creek contract, and Mr. Scott having concluded, after the preparation of a detailed map of the locality, that the proposed dike would not answer the purpose for which it was designed, recommended that the release be granted. For the reasons assigned by Mr. Scott, I approved of the application and you granted the release. The contract was therefore annulled, and no work has been done at Cabin Creek Shoals.

Elk Shoal.—Half a mile below Charleston, and fifty-seven miles above the mouth.

The dam at this point has been completed. The total amount of stone in the dam is 4,427 cubic yards. The original improvement consisted of a narrow chute, varying in width from 110 to 120 feet, bounded on each side by walls composed of loose stone and of material dredged to make the chute. This method of improvement was useful to packets, but injurious to coal-fleets, as the chute was too narrow for their use, and in consequence they ran entirely outside of it whenever the stage of water would permit. To remedy this, the right wall of the chute was removed, and the opening was made 100 feet wider, but the space taken in was left at a higher level than the bottom of the chute, in order not to increase the width of channel in dead low-water. This work was done by hired labor and has been completed. It necessitated the removal of 4,300 cubic yards of stone, gravel, and bowlders. The dike starts at the right bank, and connects with the new right-hand wall of the chute.

Two-mile Shoal.—Two miles below Charleston, and fifty-five miles above the mouth.

The dam at this place has been completed. There were used in its construction 4,128 cubic yards of stone and 79 cords of brush. It was built in order to stop the waste of water behind Blaine's Island.

REMOVING OBSTRUCTIONS.

My last annual report (p. 507, Report of Chief of Engineers, 1873) described the large grapple which I had caused to be made for use on the Great Kanawha and Ohio rivers, its special use being to raise large bowlders lying in the bed of the river, and too large to be lifted by any ordinary hoisting-apparatus. This machine has done admirable service, although it can only work occasionally, when the river happens to be low and clear.

In October, 1873, 112 large rocks and 10 snags were removed, and three wrecks of sunken coal-barges were torn to pieces in fourteen days.

The grapple was not used in the Kanawha again until July, 1874. During this month its work was as follows:

Cabin Creek.—Took 18 rocks from foot of shoals; deposited them in 11 feet water above Ault's Landing. Two lying in the right of channel were too large for the grapple, and were blasted and removed.

Witcher's Creek.—Removed from foot of shoal a large sycamore 100 feet long.

Machine Ripple.—Took twelve rocks from this place. Several of them were large and badly spike-marked.

Campbell's Creek.—Removed several logs from this landing.

Two-mile Shoal.—A large stump from Young Two-mile, and two logs from channel at mouth of creek.

Island Shoal.—Removed a stump 6 feet in diameter from foot of chute.

Tyler Shoal.—From head of chute, 4 big bowlders.

Peeled Maple.—Took out 25 big rocks and a large root.

One mile above Coal's Mouth.—Moved Christy's Rock to left shore.

Coal's Mouth.—Took a sycamore 100 feet long and 5 feet in diameter, with a bad root, from the landing.

Scary.—Removed 4 rocks and a snag from head of chute.

Near George Wright's Landing.—Took 2 big elms and a large rock from the middle of the river.

Tacket Shoal.—Four rocks from foot; one of them was very large and badly rubbed and marked.

Two mills below Tacket.—Took a large snag from the middle of the river.

Summer's Shallows.—Blasted and took out 2 large rocks.

One mile above Red House.—Blasted, and removed in five pieces a well-known troublesome rock.

Red House.—A big rock and a small snag from foot of shoal.

Little Hurricane Ripple.—Removed 9 rocks from head of chute.

Washington Shallows.—Thirteen bowlders.

Tucker's Creek Bar.—Took off 13 rocks.

Big Hurricane.—Moved 14 large rocks from this ripple.

Gillespie's Ripple.—Fifteen rocks from head; one, very large, was blasted and taken out, and a large sycamore from foot of ripple.

Vintreaux Shallows.—Nearly four days were spent in these shallows; in all 91 rocks were removed; several of them had to be blasted.

Mary's Shallows.—Took from lower end 23 rocks.

Knob Shoal.—Removed 4 dangerous rocks from foot.

Buffalo Shoal.—Removed 32 rocks here, several of them very large; considerable time spent.

Buffalo Shallows.—Removed 20 rocks; also a big snag from opposite Widow Sibbrell's landing.

Near Atkinson's Landing.—Took out a snag and 4 rocks.

Eighteen-Mile.—A bad rock from the ripple.

Arbuckle Shoal.—Removed 3 rocks from head and a very large elm from foot of chute.

Thirteen-Mile Shoal.—Six rocks and 4 troublesome logs.

Ten-Mile.—Two very large trees.

Three-Mile Bar.—Took out a bad sycamore snag about 75 feet long.

The Kanawha board were so much pleased with the work of this grapple in removing from the river many large rocks, that for years had been the terror of pilots, that at their request I had a design prepared for the smaller grapple, to be used by them in removing the smaller rocks, for which the large grapple was not well fitted.

PURCHASE OF MAPS.

The general map of the river which we use, was made by Messrs. Lorraine and Byers in 1856-'57. The set transferred to me by Major Craighill was incomplete, but negotiations were then in progress for the purchase from the widow of Mr. Byers of the missing maps and profiles. With the approval of yourself and of the Secretary of War, I purchased these documents from Mrs. Byers for fifteen hundred dollars. Our general map is therefore complete.

During the year, Mr. Scott, with one assistant, has been employed in copying and arranging the purchased material, and in making detailed surveys at places where improvements were contemplated. Detailed maps on a scale of one inch to 200 feet have been made of Cabin-Creek Shoal, Witcher's Creek Shoal, and of the river from Charleston to the foot of Wilson's Island.

NEW APPROPRIATION.

At its last session Congress appropriated \$25,000 for the improvement of the Great Kanawha. As I have been directed to transfer the charge of this river to Major Craighill, I offer no project for the expenditure of this sum, nor do I submit any estimate for the fiscal year 1875-'76.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$25,000 00
Deduct amount expended in last fiscal year.....	352 98
Amount appropriated by act approved June 23, 1874.....	25,000 00
Amount expended during the fiscal year ending June 30, 1874.....	14,322 21
Amount available July 1, 1874, (\$35,324.81—\$300.54).....	34,524 27

N 6.

IMPROVEMENT OF THE WABASH RIVER.

Mr. F. Stein has been my assistant engineer in local charge of this work.

The work of snagging and dredging in the lower end of the river and the rock-excavation and construction of wing-dam at Coffee Island Chute, all of which were under contract with Mr. R. Mackenzie, dated August 27, 1872, have been completed, and the contracts closed. The following is a summary of the work done under this contract:

Snagging in the lower river, 134 days.

Dredging in the lower river, 115 days.

Rock-excavation at Coffee Island Chute, 10,809.65 cubic yards.

Wing-dam at Coffee Island Chute, 40,307 cubic yards.

Of this work 103 days' snagging, 79 days' dredging, and 6,450 cubic yards rock-excitation were done in the fiscal year 1872-'73, as previously reported. The remainder was done during the last fiscal year.

The river is now clear of snags and obstructions, and has had its channel dredged for a distance from its mouth of 31 miles. The improvement of Coffee Island Chute one hundred and three miles above the mouth does not connect immediately with the improvements on the lower end of the river, but this place was selected by my predecessor, Major Weitzel, because at the time the available funds were insufficient to complete any more important improvement.

Under the appropriation of March 3, 1873, (\$50,000,) a contract was entered into with Messrs. Myers and De Ham for 23,000 cubic yards of rock-excitation at the Grand Chain, thirty-eight miles from the mouth of the river. This work was begun during the month of August, and was continued until December; 14,710 cubic yards of excavation were made during this time, leaving 8,290 cubic yards still to be removed. The contract provides that this work shall be completed by December 1, 1873, and work on it is now in active progress.

The next point which is in pressing need of improvement is the Grand Rapids, one hundred and twelve miles from the mouth of the river, at which place the ruins of a lock and dam constructed by the Wabash Navigation Company aggravate the natural condition of things, and render these rapids impassable, except in high stages of water. I would respectfully refer to my last annual report (Report of the Chief of Engineers for 1873, p. 511) for a full history of the lock and dam and its present relation to the improvement of the river.

Deeming it indispensable that the Grand Rapids should be overcome by the reconstruction of a lock and dam, a special survey was commenced, and at the close of the fiscal year was still in progress, to determine whether the new lock should be built upon the site of the old one, or be placed about two miles further down and just below the mouth of White River. The advantages of the latter location are that a lock and dam here would obviate the necessity of any further improvement of the White River Shoals, and would at the same time improve the navigation of the White River. Since the close of the fiscal year this survey has been completed, and from it I conclude that, on account of the lowness of the banks of the Wabash and of the White in the vicinity of the proposed site at White River Shoals, it would be inexpedient to remove the dam from its present position, and therefore I recommend the retention of the old site.

An appropriation to rebuild the Grand Rapids Lock was asked for in my last annual report, but, by act of June 23, 1874, Congress appropriated only \$25,000 for continuing the improvement of the Wabash River, adding a proviso:

That a portion of this appropriation, not exceeding \$9,000, may be used by the Secretary of War, in his discretion, for the extinguishment of any right, title, or claim of the Wabash Navigation Company in the lock and dam at Grand Rapids, on said river, and other property said company may claim on said river; and for the extinguishment of any right said company may have to affect or interfere in any way with the navigation of said river; but no part of this appropriation shall be expended until said navigation company shall have relinquished all right to control or otherwise, in any manner, interfere with or affect the free navigation of said river.

This proviso forbids any new work on the Wabash until the rights of the Navigation Company have been extinguished. A proposition for the sale of their rights and franchises has been received from this company, and has been referred to the proper authorities for action. After the purchase is made, a project for the application of the remainder of this appropriation will be submitted to the Chief of Engineers.

ESTIMATE FOR YEAR 1875-76.

For rebuilding the Grand Rapids Lock.....	\$110,000
This sum does not include the amount necessary for reconstructing the dam, as it is thought better to defer the building of this part of the work until the completion of the lock, for which at least one season will be required.	
For clearing out the chute east of the Little Chain.....	6,000
This is one of the points named by Major Weitzel for improvement in his report dated January 4, 1872, (Report to the Chief of Engineers, 1872, p. 472.) The object of this estimate is simply to remove snags, large numbers of which have lodged here. It is expected that when these are removed the action of the current will sufficiently widen and deepen this chute, and thus enable steamboats to entirely avoid the Little Chain.	
For contingent expenses.....	14 000
Total	130,000

The construction of a dam at New Harmony to close the cut-off at that place, and thus retain in the main channel the whole volume of the river, is very much needed. I have omitted this work from the above list, because I hope to be able to build this dam out of what is left of the year's appropriation after the purchase of the lands and franchises of the Navigation Company.

A statement of the financial condition of this improvement is hereto annexed.

Financial statement.

Balance in Treasury of the United States July 1, 1873	\$65,000 00
Amount in hands of officer and subject to his check, (including \$2,772.83 percentage due on contracts not yet completed).....	5,542 40
Amount appropriated by act approved June 23, 1874	25,000 00
Amount expended during the fiscal year ending June 30, 1874.	47,558 35
Amount available July 1, 1874, (\$47,984.05—\$2,647.80)	45,336 25
Amount required for the fiscal year ending June 30, 1876	130,000 00

N 7.

WATER-GAUGES ON THE MISSISSIPPI RIVER AND ITS PRINCIPAL TRIBUTARIES.

No annual inspection was made during low-water of last autumn, the proper season for inspecting, as Lieutenant Mahan, to whom I had assigned this duty, was suddenly ordered by telegraph to proceed to Savannah, and I had no one whom I could send in his place. As the gauges were generally in good order, I thought it advisable to dispense with an inspection, and to put the sum thus saved into the reconstruction in a permanent manner of such gauges as were located where the banks were of sufficient stability to permit such construction.

Fort Leavenworth gauge.—This gauge is in good order, and has given no trouble during the past year. The Missouri River was closed by ice from the 4th to the 27th of January, and from the 31st of the same month to the 4th of March, though during this period it was frequently open in places. The first ice in the river was on the 28th of November. Mr. W. N. Metz is still the gauge observer.

Rock Island gauge.—This gauge is a permanent one, being cut on the pivot-pier of the draw of the Government bridge. The first floating ice appeared in the latter part of November. The ice began to break up about 3 p. m. on the 8th of March, (gauge reading, 11.40,) and gorged at 4 p. m., opposite Rock Island water-works, (gauge reading, 14.90

and 15 at 5 p. m.) On the night of the 9th the water rose to 15.75, but the gorge held fast. On the 10th, the ice finally moved off. Mr. G. F. Evans has been the gauge-observer throughout the year.

Saint Louis gauge.—Since the date of my last report I have had a substantial iron gauge constructed on the city wharf at the place where the old records were taken by levelings, before the signal-service gauge was placed at the elevator. The exact location of the gauge is opposite No. 4 South Front street. The construction is similar to that first used at Memphis, and described in my report of February 19, 1872. (Report of Chief of Engineers, 1872, p. 426.)

Piles from 10 to 15 feet in length, and 8 feet apart, were driven on the line of the gauge. These were capped by an 8-inch stringer, and on this was firmly spiked a railroad-rail. The paving of the wharf was then re-set close up to the rail, leaving nothing visible after the work was done but the top of the rail, on which the gauge was marked with steel stamps. The zero of the new gauge is the low water of 1863. The reading on it of the city directrix is 33.81. The gauge extends to 2 feet below low-water, its lower end being supported by two extra piles and beams. For its engineering, I am indebted to Mr. Julius Rapp, assistant to Mr. J. B. Moulton, the city engineer. The latter gentleman gave me all the facilities of his office, and whatever assistance and information I needed.

In order to correct erroneous back records, I directed Mr. Leopold, the gauge-observer, to take synchronous observations on the gauge at the elevator, and on the new iron-gauge. These observations did not give very satisfactory results, as the difference in the readings varied at the same stage in the river. After comparing the differences graphically and numerically, I established the following table of corrections, to be applied to the readings on the gauge at the elevator :

Between 4 and 7 subtract.....	0.60
Between 7 and 11 subtract.....	0.20
Between 11 and 14 subtract.....	0.90
Between 14 and 17 subtract.....	1.00
Between 17 and 19 subtract.....	1.05
Above 19 subtract.....	1.10

The gauge-records which I send herewith have been corrected on this system.

Mr. Jacob Leopold continues to be gauge-observer.

Cairo gauge.—As Cairo is the most important point in the Mississippi Valley for water-gauge observations, I had even stronger reasons for constructing a permanent gauge here than at St. Louis. The old gauge at the freight-warehouse had become warped by the sun and injured by the chains and cables of steamboats, and besides it was at a distance from the main wharf. The place chosen for the new gauge is at the lower end of the paved wharf at the foot of Fourth street, the old one having been at the foot of Fifteenth. The distance between the two gauges is 2,830 feet.

Owing to the instability of the Cairo levee, Mr. Charles Thrupp, the engineer in charge, thought it advisable to support the stringer on small trestles with mud-sills. These trestles have 6 by 8 inch caps, 6 by 6 inch posts, and a 12 by 4 inch mud-sill. The posts are fastened to the cap by tenons and treenails, and to the sill by wedges and spikes. The stringer is of oak, with a section 8 by 12 inches, and is firmly fastened to each trestle-cap by $\frac{3}{4}$ -inch screw-bolts. The trestles are 4 feet in height and 6 feet apart. The gauge proper is an iron bar 4 by $\frac{1}{2}$ inch countersunk into the stringer. The gauge is a first-class one in

every respect, and reflects great credit on Mr. Thrupp. The zero of the new gauge is at the same level as the zero of the old one. Mr. M. S. Ensminger, the city wharf-master, continues as gauge-observer.

The following bench-marks in Cairo were communicated in December, 1867, to my predecessor in charge of the Ohio River, Mr. W. Milnor Roberts, by Mr. J. P. Hely, engineer, Cairo City property. They are here recorded for future use. They are referred to the city datum-line, which reads on the United States gauge 9.16.

Grade of Ohio levee.....	42.00
Grade of the Illinois Central Railroad on Ohio levee.....	43.00
Grade of Mississippi levee.....	44.00
Door-sill St. Charles Hotel, northeast corner.....	43.26
Door-sill Adler's store, between Fourth and Sixth.....	43.63
Door-sill Donnelly's store, between Eighteenth and Twentieth.....	43.78

Upper Louisville gauge.—The observer at this station has also charge of the gauge at the foot of the canal, the two gauges being about two miles apart. The upper gauge is also repeated on the wall just above the guard-gates, in close proximity to the lower gauge. I therefore concluded that it would be better to stop reading the gauge at the head of the canal, and to take both readings at the guard-gates. The readings herewith forwarded were thus taken.

Lower Louisville gauge.—In my last report I stated that the stone-cutter who cut the first gauge had made an error which amounted to about 5 inches in the highest reading. With the assistance of Capt. M. B. Adams, Corps of Engineers, who kindly superintended the work, I have had a new gauge cut at the foot of the canal which is correct. Mr. William Reynolds was the gauge-observer until May 3, since which time the record has been kept by Mr. J. B. Thompson.

Nashville gauge.—There being no gauge on the Cumberland River, I asked Mr. S. Thayer Abert, then in charge of the work on the Cumberland River, to construct one for me at Nashville, requesting him, if possible, to put in an iron-gauge. As the natural shore at the Nashville wharf is solid rock, the method of constructing the substructure varied somewhat from the method used at St. Louis and Cairo.

The following is taken from Mr. Abert's report:

The trench for the foundation has been excavated, partly in rock, partly in compact clay. Upon this bed, sills 6 by 6 inches by 4½ feet, placed every 6 feet, support a continuous string-piece of the same dimensions and 12 feet long, halved and spiked at the joints and the sills beneath. Upon this, rolled iron, 4 by ½ inches by 16 feet, is laid, with ends abutting, and secured to the string-pieces with four 1-inch spikes at distances apart of 1 foot, and upon alternate edges of the iron. Screws were used at road-crossings, as the cedar, although five times as durable as oak, does not hold nails so well. The gauge is protected from 18 inches to 2 feet on each side with substantial paving. The upper end terminates on Front street, but does not cross it. The observation of floods above this point must be transferred to the marks on Harrison's store. A line has been cut, at every distance equivalent to one vertical foot, with a cold-chisel. In some cases these marks cross the iron obliquely, on account of the difference of level in the two sides; a small difference in elevation making a noticeable difference in distance.

The low-water reference is 1 foot below the low-water of last summer, and very near extraordinary low-water. The following levels are referred to the same zero:

Top of second course of Wood & Simpson's boiler-shop.....	33.768
Top of curb-stone at lamp-post, Harrison's corner.....	48.811
Top of curb-stone at southwest corner Broad and Front streets.....	50.097
Top of sill-course, (marked x,) Harrison & Son's corner.....	50.708
True high-water mark, Harrison's corner, notched 1847.....	51.667
High-water mark in paint, Harrison's corner, 1847.....	55.167

The entire length of the gauge is 304 feet. High-water mark 54.667 is 165.000 on the city-levels. Regular gauge-observations began on the 17th of August, 1873. Mr. H. H. Harrison is the gauge-observer.

Florence gauge.—This gauge has required no repairs during the year. Mr. W. P. Stradford is still the gauge-observer.

Memphis gauge.—This gauge was partly constructed by me and partly by the city of Memphis, (Report of Chief of Engineers, 1872, p. 430.) I regret to state that the lower portion of the city's part had to be taken up on account of the caving into the river of that part of the wharf on which it was built. This gauge therefore needs repair. It will be difficult to make a permanent gauge at Memphis until the city protects the foot of its wharf below low-water by riprap or similar covering. I urged this when the gauge was first constructed, but without succeeding in getting my recommendations adopted. Mr. W. L. Trask continues as gauge-observer.

Jacksonport gauge.—No repairs have been needed on this gauge during the past year. Mr. W. E. Bevins is still the gauge-observer.

Little Rock gauge.—The lowest section of this gauge is of wood, fastened to the vertical timber-wall at the foot of the wharf. During very low water, mud and sand accumulate so rapidly at the foot of the gauge that a trench must be dug every morning to get an observation. I thought of remedying this difficulty by duplicating the lowest section of the gauge by cutting it on the rocks above the landing. The lowest bid I could get for this work was \$150, and therefore I abandoned the idea. On the night of the 5th of February the brick house to which the upper section of the gauge was attached was destroyed by fire, but the gauge, which was fastened on the outer wall of the cellar, was not injured. Since that time the owners of the building have been ordered by the city authorities to take down the walls. The gauge needs inspection and probably a partial reconstruction. Mr. Joseph Meyer is still the gauge-observer.

Helena gauge.—The gauge at this place was injured in July, 1873, by a coal-barge standing on it, but the observer made temporary repairs and kept it in fair condition. In June, 1874, he reported that the gauge needed reconstruction, as some of the sections were inaccurate from settlement, and others had been injured by drift and barges. He thought that the bank should be graded, and a heavier gauge constructed. I authorized this work to be done, but directed that the gauge should not be marked without orders. The reconstruction of the gauge is yet incomplete. Mr. J. B. Miles continues to be gauge-observer.

Gauge at mouth of White River.—This gauge needs a total reconstruction, and it may be advisable to change its location to Terrene, on the Mississippi shore. In my last report I stated that the old gauge had been carried away by the caving of the banks. Being unable to send any one to White River at the time, I directed the observer to make a new gauge on the plan of the old one, and mark it as accurately as he could. This gauge also was destroyed in June, 1874, and the observer was directed to reconstruct it, the greater part of the material having been saved. This has not yet been done, and the record is kept by temporary marks. Capt. F. C. Kendall has been the observer during the year.

Lake Providence gauge.—In July, 1873, the falling of the river revealed the fact that below the 24-foot mark the gauge was gone, probably destroyed by the ice of the preceding winter. The record has since then been kept up by temporary stakes. The gauge probably needs reconstruction. There is a duplicate high-water section of this gauge that will keep an accurate record of floods, even should the whole of the original gauge be washed away. Mr. S. T. Le May is still the gauge-observer.

Vicksburg gauge.—The observer of this station reports that he thinks that the elevator-piles to which the gauge is attached have settled, and he recommends an instrumental examination. This matter, however, has been unavoidably postponed. Mr. D. P. Fithian has been the gauge-observer during the year.

Natchez gauge.—There has been no trouble with this gauge during the past year. The bench-mark on Mrs. Cann's house having become endangered by the rotting of the wooden door-sill, the observer had a new bench established on the iron door-sill of Ray & Grant's store. Mr. L. F. Carvey was the observer from April 27, 1873, until his decease, on the 11th of August, 1874. The gauge is now under charge of Mr. J. B. O'Brien.

Red River Landing gauge.—On August 3, 1873, the observer at this station reported that the lower section of the gauge was missing. It was temporarily, but erroneously, established by a local engineer, and finally reconstructed by Mr. C. W. Babbitt, of Natchez, whom I sent there for that purpose. He found that 36 feet of the gauge required reconstruction, due to the slipping of the banks and the shock of a loaded barge. Maj. A. D. Smith continues to keep the gauge-records.

Alexandria gauge.—The lower section of this gauge was frequently broken by steamboats striking against it, so that it became necessary to reconstruct it more securely. The observer employed Capt. R. W. Bringham, the parish surveyor, for this purpose. He used 8 by 10-inch stringers, on uprights of the same cross-section, 3 feet in length, supported on sandstone. The top of the stringer is even with the natural surface of the bank. The length of gauge replaced was 56 feet. Notwithstanding the care taken, the gauge was again broken in February. It could not be repaired until the present month. Capt. J. A. Williams has been the observer since the gauge was established.

Baton Rouge gauge.—On the 5th of July, 1873, the observer reported that the second upright post was missing, and that a part of the inclined gauge was gone. The damage is supposed to have been done by a raft-log. A temporary post was at once put in the place of the missing one. As the water continued to fall, it was found that the lowest post was out of plumb, having been struck by a raft. This post was straightened and made serviceable. In October the gauge was carefully examined and put in good order by Mr. J. T. Van Pelt, civil engineer. His report contains the following interesting items, that should be preserved :

It may be deemed important by the Department to have on record the following connections, or points of reference, which have been made by me at various times, and which have been carefully checked :

Mark on northeast corner of chimney of old mill near the gauge.....	35. 909
Top of stone bourn, at boundary-line between United States garrison and city property.....	34. 111
Bench-mark on State-house, known as the State-house bench-mark, which I think that Colonel Merrill used as his starting-point	62. 570
Low-water 1854, (by Waller's records = 62. 370 below State-house bench-mark)	0. 200
Low-water 1861, (by Waller's records)	3. 200
High-water 1851, (by Waller's records = 34. 33 above low-water 1854)	34. 530
High-water 1862, (by Waller's records = 35. 870 above low-water 1854).....	36. 070
High-water 1869, (measured by a citizen, 4½ inches over the stone bourn)....	34. 486
High-water 1871, (observed at the time by Van Pelt).....	34. 520

The above readings differ somewhat from those of Colonel Merrill in 1872, but they are the result of three lines of levels run, first, by S. W. Hill, April 20, 1871; second, by myself, May 20, 1872; and, third, by myself and Colonel Lockett March 31, 1873. The three sets of levels, and especially the last two, agree closely. The above is an average of results.

These results are doubtless more correct than mine, which were obtained very hurriedly and under unfavorable circumstances, and I think that they merit preservation. Colonel Lockett resigned his post as gauge-observer in June, 1873, since which time the gauge has been in charge of Mr. W. N. Van Pelt, the business-clerk of the University of Louisiana.

Carrollton gauge.—In March, 1874, the observer at this gauge reported that two of the sections of the gauge which overlapped differed 0.15 in their readings. I at once wrote to Captain Howell, Corps of Engineers, and requested him to have the gauge examined. He directed Lieutenant Quinn to make the examination, and the latter reported that the section nearest the shore had settled 0.262 foot, and the next section 0.162 foot. The other sections were under water. Captain Howell promised to have another examination made in low water. On the 3d of the present month (August) the observer informed me by letter that the wharf had slipped into the river, carrying with it the gauge and its nearest bench-mark. Mr. William B. Williams, civil engineer, was employed to put in a temporary gauge, and observations for the present are taken from it. Mr. W. L. Duffy is still the gauge-observer.

Having at my own request, made on account of the pressure of other duties, been relieved from the future charge of these water-gauges, I will add a brief classification of them, as they appear to my mind after three years' experience.

The gauges at Rock Island, St. Louis, Cairo, Louisville, and Nashville may be considered as entirely permanent. Those at Fort Leavenworth, Jacksonport, Florence, Memphis, and Little Rock as semi-permanent; but the others require constant watching and continual repairs. The most suitable station for the officer in charge is at the point most central to the unstable gauges, and this condition is admirably filled by Vicksburg, the station of my successor. The system thus far carried out has been of great value to the planting and navigation interests, and I strongly recommend its continuance. It is for this reason that I have made all the gauges as permanent as their sites would permit. The Cairo gauge is much the most important of the system.

RECORDS OF THE FLOOD OF 1874.

I directed all gauge-observers to send to this office all information that they could obtain about the flood of this spring. I had intended compiling this information for this report, but as the whole subject has lately been referred to an engineer board, to whom I have been directed to turn over all the information in my possession, it is evidently unnecessary for me to discuss the subject.

I send herewith the gauge-records for the fiscal year 1873-'74 at the above-mentioned gauge-stations. The St. Louis record commences in 1861, and would have been forwarded last year but for certain errors, which have since been corrected.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$5,000 00
Amount in hands officer and subject to his check.....	813 37
Amount allotted from appropriation of June 23, 1874, for examinations and surveys.....	5,000 00
Amount expended during the fiscal year ending June 30, 1874.....	5,787 16
Amount available July 1, 1874	5,026 21

N 8.

EXTENSION OF THE CHESAPEAKE AND OHIO CANAL TO THE OHIO RIVER.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, March 20, 1874.

GENERAL: The act of Congress approved March 3, 1873, making appropriations for rivers and harbors contained the following clause: "And not to exceed \$5,000 of the above appropriation may be expended in an exploration of routes for the extension of the Chesapeake and Ohio Canal to the Ohio River by the north and south branches of the Potomac River."

The duty of making this exploration having been assigned to me, and being unable, on account of my other duties, to make the survey in person, I considered myself fortunate in being able to put it in charge of Col. Thomas S. Sedgwick, late of the volunteer service, who had served under my command in the earlier years of the late war. His report is herewith forwarded.

The idea that there ought to be a canal from tide-water to the Ohio, via the valley of the Potomac, is a very old one, and was a favorite scheme of Washington, who was a stockholder in the Potomac Company, an organization that began work by attempting to improve the channel of the Potomac. Their efforts, however, were abortive, and the project slumbered until it was revived in 1824, under the auspices of the National Government. During this year, and 1825 and 1826, very careful surveys were made along the entire line of the proposed canal from Washington to Pittsburgh, special care being given to the manner of crossing the mountains. The results of these investigations are given in the copies of the Reports of the Board of Internal Improvements, which are herewith attached as Appendix A.

The object of the surveys of fifty years ago was to discover a practicable water-route between the Potomac and the Ohio. As the eastern division of the proposed canal (that portion lying in the valley of the Potomac) has been built as far as Cumberland, I inferred that my duty was to ascertain how to extend this canal toward the Ohio. The act itself required the survey to be made "by the north and south branches of the Potomac." As the limited sum at my disposal made it impracticable to run more than one instrumental line, and as the south branch of the Potomac enters the main river seventeen miles below the present head of the canal, and flows from a direction almost at right angles to the general line of canal, if Pittsburgh be considered as its objective point, I decided to restrict the examination to the north branch of the Potomac. Mr. Benjamin Latrobe, late chief engineer of the Baltimore and Ohio Railroad Company, very kindly placed at the service of Colonel Sedgwick all of the information which he had acquired while surveying to ascertain the best route for a railroad over the mountains, and gave it as decidedly his opinion that it was useless to seek, south of the Baltimore and Ohio Railroad, for a pass through which to carry a canal whose western terminus was designed to be at Pittsburgh. If there were an intention of making a connection with the proposed James River and Kanawha Canal, then the valley of the south branch of the Potomac should be surveyed, but inasmuch as I could hear of no such intention among those interested in the extension of the Chesapeake and Ohio Canal, and as such a canal, even if built, would probably be unable to divert any through traffic from the shorter

and easier line down the James River, I concluded to abandon the south branch entirely. This survey was therefore restricted to a line via the north branch of the Potomac.

The Board of Internal Improvements, in 1825, reported a feasible route via North Branch, Savage River, Crab-Tree Creek, Deep Creek, and the Youghiogheny. In 1826 they reported a much better route, at a lower elevation, by way of Wills Creek, Flaugherty's Creek, and Casselman's River to its junction with the Youghiogheny and the other canal line. The route over the mountains, which Colonel Sedgwick selected for examination, was intermediate between these two. Commencing at Cumberland, it followed the North Branch, Savage River, and Blue Lick, and then, by a tunnel, struck Casselman's River at the Plucher reservoir of the Wills Creek route; thence it followed down the Casselman until it joined the Wills Creek route at the mouth of Flaugherty. The details of these three routes are given in the accompanying documents.

The following is a tabulated statement of the more important features of the three routes between Cumberland and the mouth of Casselman. The route recently surveyed is called, for distinction, the Savage River and Blue Lick route.

Comparison of lines for crossing the mountains.

Routes and dimensions.	Deep Creek route.	Wills Creek route.	Savage River and Blue Lick route.
Length from Cumberland to mouth of Casselman.....miles..	88.59	70.57	100
Length of tunnel at summit.....miles..	1.33	4.05	5
Elevation of summit-tunnel above tide.....feet...	2,408	1,972	2,100
Lockage from Cumberland to tunnel.....feet...	1,804	1,368	1,496
Lockage from tunnel to mouth of Casselman.....feet...	1,070.5	634.5	762.5
Total lockage between tunnel and mouth of Casselman.....feet...	2,874.5	2,002.5	2,258.5
Length of summit feeders.....miles..	12.0	6.0	6.1

In preparing the above table it became necessary to determine the elevation above tide of the Cumberland bench-mark. The surveys of 1828, and the construction of the canal, showed that there was an error of 69 feet in the levels of the eastern section of the canal as surveyed under the direction of the Board of Internal Improvements. The bottom of the canal at Cumberland is 603.75 above tide, and its surface 609.75. The Government bench-mark was found to be at the elevation of 632.27 feet above tide. An error in leveling was also found between Cumberland and the Wills Creek tunnel. As the latest survey put this tunnel definitely at 1,972 above tide, that height has been considered as established, and the Deep Creek tunnel has been placed 436 higher, according to the relative difference of level found by the Board of Internal Improvements. The lockages up to the three tunnels have been calculated from the present level of the canal at Cumberland.

A slight examination of the above table shows that the Wills Creek route is greatly superior to the other two, being shorter than either of the others, and having a much lower summit-level. It is eighteen miles shorter than the Deep Creek route, and has 872 feet less lockage, which is equivalent to dispensing with 109 locks. It has a longer tunnel, but this disadvantage is more than counterbalanced by the other great advantages. As compared with the Savage River and Blue Lick route (the new route surveyed by Colonel Sedgwick) it is twenty-nine and a half miles shorter, has 256 feet less lockage, and its summit-tunnel is

one mile shorter. It is, therefore, a better route in every respect. Comparing the Deep Creek route with that by Savage River and Blue Lick we find that the former is eleven miles shorter and has a much shorter summit-tunnel, but has 616 feet more lockage. As far as time of transit is concerned we may assume that eight minutes are required at each lock for passing a boat through, which is equivalent to one minute for each foot of lift. The 616 feet of extra lockage would therefore require six hundred and sixteen minutes, or ten hours and sixteen minutes, during which time a boat could travel thirty-one miles on a level. As far, therefore, as speed of passage is concerned, the new route is twenty miles shorter in distance, or six hours and forty minutes quicker in time, than the Deep Creek route.

But there is always difficulty in maintaining enough water for navigation in very short levels, and therefore it is very desirable to have the locks as far apart as possible. Both of the last-mentioned routes follow the same line going west as far as the mouth of Crab-Tree, and therefore we need only compare them west of this point. On the Deep Creek route the heads of the lock would be at an average distance apart of 351 feet, but the Board state that "this is on the supposition of a uniform declivity, which is far from being the case, and more especially in the valley of Crab-Tree Creek, where, toward the head, the locks on account of the steepness of the ascent could not even find room, unless their lift should be considerably increased. To this difficulty we must add the narrowness of the valley, which would oblige to resort to very expensive means to erect, where necessary, double sets of locks, as also to shelter the work from destruction either by high freshets or by heavy showers."

On the Savage River and Blue Lick route the average distance between the heads of locks from the mouth of Crab-Tree to the eastern portal of the tunnel is 651 feet, and there is no difficulty in preserving this average throughout this part of the line. This is a very great advantage. Another advantage is that the new route, immediately after crossing the summit, enters a rich coal-basin (the Salisbury) on the other side of the mountains. As far as known, the country on the Deep Creek route, between the mouths of Crab-Tree Creek and Castelman River has no mineral resources and would furnish but little business to the canal.

If, therefore, a choice were necessary between the Deep Creek and the Savage River and Blue Lick routes, I think that the preference should be given to the latter, although it is proper to state that the long summit-tunnel will cause detentions that will appreciably reduce the gain in time over the Deep Creek route.

An inspection of the map shows that the only other possible route for a canal between Cumberland and Pittsburg, besides those already examined, is by way of the North Branch to its head, and thence across the mountains to the Cheat River. To this route there are several objections.

1. The approximate height of the head-waters of the North Branch at Fairfax Stone (as shown by Colonel Sedgwick's reconnoissance) is 2,520 feet above tide, showing that a tunnel in this vicinity would have a greater elevation than on any other line, and that, therefore, this line would require a much greater number of locks.

2. If the canal did not turn off before reaching the head-spring, it could not be supplied with water.

3. A route by the North Branch and Cheat River would be greatly longer than by any other line.

4. The Cheat River is an exceptionally wild and difficult stream, and

the maintenance of a canal alongside of it would be very difficult and costly.

(For a description of Cheat River see Appendix A, page 513.)

5. Along this line the country is very sparsely settled, and there would be but little business for a canal.

Any route passing south of the North Branch would be still more objectionable.

We therefore conclude that, in extending the Chesapeake and Ohio Canal, the choice of routes is absolutely limited to the three mentioned above. In order of desirability they are as follows:

1. Wills Creek route.
2. Savage River and Blue Lick route.
3. The Deep Creek route.

As by the appropriation act I was debarred from having an instrumental examination made of the Wills Creek route, my knowledge of it is limited to the older surveys and what could be seen while passing over the railroad between Cumberland and Pittsburg, which, except at the summit, occupies throughout its whole length the location chosen for the canal. The valley of the Little Wills Creek is so narrow and so wild, that it is doubtful if the railroad has left room for a canal; but this route is so greatly superior to any other, that, in my opinion, no work should be done toward extending the canal until a very careful examination is made of this line, to ascertain if it is still practicable for a canal. As far as the Salisbury coal-basin is concerned, it could more readily be reached by the Wills Creek route (if the feeder from Pleucher's were made navigable) than by the Savage River and Blue Lick route, as the distance from Salisbury to Cumberland via Wills Creek is forty-three miles, while by the Savage River it is fifty-seven.

But a canal by any of these routes is so very costly, that local advantages must be entirely subordinated to the principal object of the expenditure. In this case a connection between the Potomac and the Ohio is the evident solution desired, and therefore the line chosen for the canal should be such as will give the most useful connection, regardless of local interests.

After crossing the mountains the next question is how to descend the valley of the Youghiogheny. No instrumental survey could be made of this part of the route, but enough was visible from the cars to indicate that there would be considerable difficulty in this valley, especially at Ohio Pile Falls. The route recommended by the Board of Internal Improvements has been occupied by the railroad from Cumberland to Pittsburg, and an effort must be made to find room for the canal on the other side of the river. I would, therefore, recommend an appropriation for this purpose.

In order to test the value of Colonel Sedgwick's estimate of the cost of the summit-tunnel, I applied to the authorities of the Baltimore and Ohio Railroad for a statement of the cost of the Sand-Patch tunnel, which is at about the same place, though at a higher elevation, as the proposed Wills Creek tunnel. Mr. Latrobe very kindly gave me full particulars, and, with his consent, I append his letter as Appendix C. This tunnel, 4,800 feet long, cost \$420,000, or at the rate of \$87.50 per running foot for tunnel and approaches. The section, in the clear, of the Sand-Patch tunnel is 16 by 18½, while that of the proposed canal-tunnel will be a segment, 26 feet in height, cut from a circle whose radius is 16 feet. The area of excavation for the Sand-Patch tunnel is therefore about 330 square feet, and that of the proposed canal-tunnel

about 800 square feet. The latter is, therefore, two and four-tenths larger than the railroad-tunnel.

Colonel Sedgwick places the cost of his five-mile tunnel at \$8,346,000, which is at the rate of \$1,669,200 per mile, or \$316 per running foot. At this rate a tunnel of the sectional area of the Sand-Patch tunnel would cost \$132 per running foot, which is 51 per cent. more per running foot than the latter tunnel actually did cost. A wide tunnel is less costly per cubic yard than a narrow one; but, on the other hand, a long tunnel is more costly than a short one. In the absence of any definite knowledge of the depth of shafts, or of the stratification of the rock through which the five-mile tunnel is to pass, we may content ourselves with the above estimate as reasonably accurate.

As corroborative evidence that this estimate is not too small, I would state that the published estimate of the cost of the summit-tunnel on the James River and Kanawha line, 7.8 miles long, is \$13,253,310. This last tunnel has a section of 52 by 34½ feet, being 46 feet wide at water-line and 7 feet deep. It is, therefore, about 70 per cent. larger than the tunnel proposed by Colonel Sedgwick.

WESTERN TERMINUS OF CANAL.

At present there is slack-water on the Monongahela to and above the mouth of the Youghiogheny. The terminus of the canal should be at this slack-water. An effort is being made to slack-water the Youghiogheny to West Newton, or higher, for the benefit of the coal-mines on this river. Although this may answer the wants of coal-operators, who can only ship coal when there is a sufficiency of water in the Ohio, at which time there is usually good water in the tributaries, it cannot be depended on as the terminus of a canal doing a large business. The Youghiogheny, in dry seasons, does not supply enough water to provide lockage for an extensive navigation, and there is sometimes trouble even on the Monongahela. The terminus of the Chesapeake and Ohio Canal should therefore be at McKeesport.

As Colonel Sedgwick has stopped his estimate at Connellsville, it is necessary to increase it by the cost of extending the canal to McKeesport. The distance from Connellsville to McKeesport is forty-four miles, and the lockage in this distance is put by the board at 152 feet. In continuing the canal to Pittsburg they have an additional lockage of thirty-five feet. As their canal was assumed to be 5 feet in depth, and as all their levels refer to the bottom of the canal, the latter must have been taken at McKeesport at an elevation of 30 feet above low water in the Ohio at Pittsburg. Between Pittsburg and McKeesport there are two dams across the Monongahela, each of which has a lift of 8 feet. The bottom of the canal at McKeesport must therefore be 14 feet above the surface of the Monongahela at the same place, and the lockage to be provided for must be 19 feet. The increase in length of canal over Colonel Sedgwick's estimate will therefore be forty-four miles, and the increase in lockage 171 feet.

The Board's estimate of cost from Connellsville to McKeesport was \$2,047,996. Increasing this by 25 per cent. it becomes \$2,559,995, and adding the cost of the three additional locks, (\$45,000 more,) we find the total cost of this section \$2,605,000. If we allow 10 per cent. for contingencies the estimate becomes \$2,865,500. This would make Colonel Sedgwick's total estimate for a canal, 33 feet wide at bottom, 48 feet wide at water-line, and 5 feet deep, and extending from Cumberland, Md., to McKeesport, Pa., a distance of one hundred seventy-one and a half miles, \$23,133,585.

SIZE OF CANAL.

The depth which Colonel Sedgwick has chosen for the canal seems to me to be inadequate to the wants of a great through water-route. I think that on no account should the extension have a less size than the canal as now built to Cumberland; otherwise the sums expended below Cumberland in providing 6 feet of water will have been wasted as far as through-traffic is concerned. The chief objection to increasing the depth of the canal comes from the increased supply of water required to keep up the levels. The increased waste in a deep canal is due to the increased filtration through the soil, and the increased leakage through gates, both of which increases are due to the greater pressure exerted by the deeper water. If the calculations of those who examined and reported on the water-supply are to be trusted, there certainly seems to be enough water available to supply a 6-foot canal, if made reasonably tight.

There seems to be no doubt that a 6-foot canal can be kept up throughout all but the summit-level without any unusual expense. If, then, special care be taken in the construction of the summit-level, so that a 6-foot canal shall hold water as well as a 5-foot one usually does, there will be no lack of water, and a slight increase in expenditure will insure a far greater increase in the usefulness of the work. If the canal can only give 5 feet depth of water its utility will hardly be sufficient to justify its construction.

The only survey which we could make was so hurried, and the quantities to be used in calculation so uncertain, that it seems hardly worth while to attempt to estimate in detail how much the estimate should be increased to provide for a 6-foot extension. If a section were assumed the same as that of the present canal at Cumberland, the water area would be increased from $202\frac{1}{2}$ square feet (as assumed by the Board for a 5-foot canal) to 252 square feet. This is an increase of $24\frac{1}{2}$ per cent. Therefore, roughly assuming a corresponding increase of expenditure, we find the cost of a canal 30 feet wide at bottom, 54 feet wide at water-line, 6 feet deep, and extending from Cumberland to McKeesport, one hundred and seventy-one and one-half miles, \$28,801,313. I think that this estimate is as fair an approximation as our limited information will now permit.

WORKING OF SUMMIT-TUNNEL.

I am decidedly of the opinion that the summit-tunnel should be worked by steam. The summit-tunnel on the Burgundy Canal in France is successfully operated by steam-tugs, towing by the use of a submerged cable. They work very economically, and in fact this system is very generally used in France on their canalized rivers. To avoid smoke, which would be very objectionable in very long tunnels, it might be practicable to carry large reservoirs of steam, supplied from boilers at each end of the tunnel, as I understand is now done in New Orleans on one of the street-car lines. The omission of the tow-path saves a very considerable sum in the cost of the tunnel, and even in case of accident to a tug there would be no difficulty in poling the boats out of the tunnel.

INCLINED PLANES.

Where locks have to be so close together, as will undoubtedly be necessary at many places on this extension, I think that it would be in every way advantageous to resort to the system of inclined planes so

successfully used on the Morris and Essex Canal. I am informed that, by this system, boats travel up and down the inclines as fast as they do on a level, and thus one of the greatest objections to a heavy amount of lockage is entirely obviated. Colonel Sedgwick has nearly finished a paper on this subject, which I will forward when completed, and which I request may subsequently be attached to this report. If the Wills Creek route should prove to be still available, I believe that its heavy ascending grade going west will make it necessary to use inclines instead of locks, at least immediately east of the summit. Boats would have to be in two parts to accommodate themselves to this arrangement. There are probably other places on the line where the same construction would be useful.

WESTERN CONNECTIONS.

It must be borne in mind that both this canal and the James River and Kanawha will utterly fail to become great through-routes of water transportation to the seaboard, unless the Ohio River is made to give a depth of at least 6 feet throughout the summer and fall, the time when the canals are doing their heaviest business, but the rivers are at their lowest. It is foreign to the present report to do more than allude to this matter, but as it is a vital one I think it proper, as the engineer in charge of the Ohio, to state that there is no practical difficulty in the way of securing this depth throughout the year by movable dams. For details reference is made to Ex. Doc. No. 127, House of Representatives, Forty-third Congress, first session. I have no hesitation in saying that it is impracticable to secure such a depth for navigation, at least above the falls, by any attempted guiding and controlling of the natural currents, however simple such operations may appear in the office. They have been repeatedly tried and found wanting. Below Pittsburgh the Ohio is often down to 12 inches, and between Louisville and Cairo it is not unfrequently down to 20 inches. For a fuller statement on the practicability of improving the navigation of the Ohio below the falls, see Ex. Doc. 127, Part 3, House of Representatives, Forty-third Congress, first session.

COMMERCIAL ADVANTAGES OF THIS CANAL.

This is a matter that I thought of working up, and for that purpose I had some statistics prepared from the last census-tables, but I have concluded that until a definite line of canal is selected, and a fair approximation of its cost is made, it will not be practicable to make a useful comparison with other through-routes. Until the profile of the canal is determined its equated length cannot be obtained, and this alone gives a basis of comparison. If this investigation is continued I will endeavor in my next report (should the survey be again confided to me) to take up this branch of the subject. In order to have a graphic comparison between this water-line, the Erie, and the James River and Kanawha, I have prepared a profile-sheet which shows each line. They all end at tide-water, the Erie beginning at Buffalo, the Chesapeake and Ohio at Pittsburgh, and the James River and Kanawha at Point Pleasant. The profiles show very clearly the immense natural advantages of the route occupied by the Erie Canal.

CONCLUSION.

In concluding this report I would recommend, as I have mentioned before, that if this investigation is to be continued careful surveys should

be made by the Wills Creek route from Cumberland to McKeesport. This would require three independent parties under the control of one chief. One party should take the line from Cumberland to Meyer's Mills, and the other two should divide the distance from Meyer's Mills to Connellsville. From the latter place to McKeesport the route is unquestionably feasible, and the old surveys will do until the work of construction on the mountain section is well under way. The entire route should be surveyed with a special view to the use of inclined planes on difficult ground, and to the location of the necessary reservoirs; for reservoirs will be needed along the whole of the line. I would not recommend any survey at present of the Savage River route. It will be time enough to take that up if it is found impracticable to get a line through by way of Will's Creek. A saving in distance of twenty-nine and a half miles, and in lockage of 256 feet, is equivalent to a saving in time of about fourteen hours, which is so great a gain as to justify a large increase of expenditure in order to secure it. The cost of the surveys recommended would be about \$20,000, and this appropriation I would recommend if this extension is to be carried through.

Respectfully submitted.

WM. E. MERRILL,
Major of Engineers.

General A. A. HUMPHREYS,
Chief of Engineers.

Report of Mr. Thomas S Sedgwick, Assistant Engineer.

WASHINGTON, D. C., January 30, 1874.

COLONEL: I have the honor to make the following report of instrumental reconnaissance and examination for the extension of the Chesapeake and Ohio Canal.

The western terminus of the canal is at Cumberland, Md., and the problem of its extension is a difficult one, arising not only from the great elevation to be overcome and the steep eastern slope of the Alleghany Mountains to be climbed, but also from the changed condition controlling the extension now as compared with those existing when the construction of the canal was begun in 1828. The route by Will's Creek and Flaherty Creek to Meyer's Mills, on Castleman River, and thence by Castleman River and the Youghiogheny and Monongahela Rivers to Pittsburg, then believed, and, in fact, fully demonstrated, to be the best and most practicable route between Cumberland and Pittsburg, is now occupied and controlled throughout its entire length by the Pittsburg branch of the Baltimore and Ohio Railroad; so that portion of the route between Cumberland and the summit of the mountain at Sand-Patch tunnel is not now practicable for the location and construction of a canal, there being also a second railroad (the Pennsylvania and Cumberland) between Cumberland and the mouth of Little Will's Creek, fifteen miles, so that the hope of the extension of the canal reasonably reverts to the Deep Creek route, the alternative route with the Will's Creek route, both which were reported on in detail by the Board of Internal Improvements in 1826.

This route follows the North Branch of the Potomac to the mouth of Savage River, and thence by the Savage River and Crabtree Creek to Bear Creek and Deep Creek, and by the Youghiogheny to the junction with Castleman River, at Turkey Foot, now confluence, a point common to the two routes.

This route is eighteen miles longer than the Will's Creek route, and its summit-level was taken 440 feet higher than the summit-level of the Will's Creek route. That portion of the route between Cumberland and the mouth of Savage River is occupied in general by the main line of the Baltimore and Ohio Railroad, but, the valley being wide and open and the railroad company having been directed by process of law to respect the prior location of the canal, which had been made as far as the mouth of Savage River, the conditions are not materially changed with regard to the location and construction of a canal between those places, excepting, probably, in the matter of land and right of way.

The favorable condition of the Will's Creek route being so disadvantageously modified by railroad occupation, the question arose as to the probability of the existence of

a route between the Will's Creek and Deep Creek routes, which could have a lower summit-level than the Deep Creek route, and which could be supplied with water from the reservoirs on Castleman River designed for the Will's Creek route, and at the same time would have a summit-tunnel of a feasible length. In accordance with these considerations it was deemed advisable, with your approval, to thoroughly examine the summit-passes between the Savage and Castleman Rivers, a region not heretofore surveyed, and to determine their character and conditions with reference to the extension of the canal thereby. Accordingly a route, beginning at the mouth of Savage River, the termination of the previous surveys, and following the Savage to Blue Lick Run, crossing the summit of the mountains near the Shades, on the old National road, and descending to the Castleman River at Salisbury, Pa., by Piney Run, was examined by instrumental survey.

This route was found to be generally favorable, especially as to the matter of a good location and cost of construction of a line of canal, though not so favorable as to the summit-tunnel. It traverses a very important and valuable coal-basin, and would provide an additional transportation outlet for the Cumberland coal-basin and enhance the agricultural growth of the valley of the North Branch and its larger tributaries. This route is longer than the Will's Creek route, but is better conditioned as to the distribution of locks and efficiency and economy of the water-supply.

THE CONDUCT OF THE SURVEY AND CHARACTERISTIC FEATURES OF THE ROUTE.

The surveying party rendezvoused at Bloomington, W. Va., near the mouth of Savage River, on the 25th of July, but owing to some delay in procuring a cook, and the slow arrival of the surveying instruments, surveying operations were not begun until August 1. The survey was begun at the junction of Savage River and the North Branch, which comes some forty miles from the southwest, runs northeasterly some thirty miles to Cumberland.

The elevation was taken to be 960 feet above tide-water at Georgetown, D. C., as determined by the surveys of 1828. This elevation corresponds with the grade-notes of the Baltimore and Ohio Railroad.

The Savage River, from its mouth to Crabtree Creek, five and a quarter miles, has a general direction west-northwest, its bed rising uniformly at the rate of 74 feet per mile. In this distance it has worn its way through and right across the axis of Savage Mountain (which lies northeast and southwest) to the depth of nearly 1,000 feet, consequently the channel is crooked, and has rough, rocky bluffs at the bends, and is the most unfavorable portion of the route in regard to location and construction. The Baltimore and Ohio Railroad holds its way high up on the southern side of the ravine, to gain the summit of the mountain at the head of Crabtree Creek. The valley is unsettled and wild, and covered with a rank growth of laurel, so that the line of the survey often followed the bed of the stream.

A gauging of the river just above its mouth gave a discharge of 18 cubic feet per second.

From Crabtree to Monroe Run, two and a half miles, the river turns sharply to the north, its bed rising at the rate of 53½ feet per mile; the valley grows wider and has no bluff or rocky banks; thence to Blue Lick Run the direction is north-northeast for five and three-quarter miles; and thence to the summit of the mountain by Blue Lick, five and three-quarter miles, the direction is north, with a convex bend to the east.

From the mouth of Crabtree the Savage River lies between the Savage Mountain on the east and the main Alleghany on the west, with a general direction north-northeast reaching some sixteen or eighteen miles, crossing the National road some four miles west from Frostburg, Md. From the mouth of Crabtree Creek to Chaney's Mill, on Blue Lick, near its head, the valley is wide and open, and has often several hundred yards width of bottom-lands; the river is without bluffs or rocky banks, and rising at the rate of 65 feet per mile. The general character of this section of the route is very favorable for the construction of a canal, there being room enough for a good location, and the hill-slopes having terraces favorable for supporting the levels of the canal to suitable sites for locks. A location can be made on the west side of the valley over this section, without difficulty or obstacles, to a point where the entrance to the summit-tunnel may be satisfactorily located.

From the summit of the mountain along Two-Mile Run to Piney Run, a distance of four miles, the direction is northeast, and thence along Piney Run to its junction with Castleman River, one mile north of Salisbury, Somerset County, Pa., the direction is north-northwest, and the distance is six and one-quarter miles, the ground falling at the rate of 79.4 feet per mile. Along Two-Mile Run, which crosses the National road at Shades, the same difficulty in surveying was met as on the first section of Savage River, and also as far down Piney as Ingle's Mill, within one mile of its mouth. From Ingle's Mill to the mouth of Piney the character of the valley is very favorable for location and construction on either side of the valley, being wide and open, with much bottom-land and meadow.

The survey having demonstrated the practicability of this route, the examination might have closed when the valley of Castleman River was reached; but, for the purpose of making a more complete comparison of this route with the Will's Creek route, the survey was continued down the valley of Castleman River to Meyer's Mills, (Meyer's Dale City,) at the mouth of Flaugherty Creek, and thence to Blue Lick, these being the valleys into which the proposed tunnels led from Bowman's Run on Will's Creek. From Piney Run to Flaugherty Creek, a distance of six and a quarter miles, the river has several great bends, making a very crooked route, with a general direction nearly north, descending at the rate of $7\frac{1}{2}$ feet per mile.

For the purpose of making close connections with the surveys of 1824 and 1823, and to aid in the identification of prominent points of those surveys, lines were surveyed three miles up Flaugherty Creek, and one and a half miles up Blue Lick. A benchmark was pointed out and identified as one made by the surveying party of 1823, under the direction of Nathan S. Roberts, chief engineer of the board of engineers of the Chesapeake and Ohio Canal. This bench was marked 1823, and under this was 1,972, the latter being the elevation of the summit-level above the tide at Georgetown. Our levels agreed with this elevation within one foot.

In addition to these examinations, a survey was made of the portion of Savage River above Blue Lick, and to the same summit by way of Mud Lick Run, the most difficult part of our work. This route was so very crooked and so much longer than the Blue Lick route, that it is not at all taken into consideration.

The whole distance thus surveyed was fifty-three miles, closing with the 1st of October. The distances here given are those made in the chaining of the survey in tracing the streams, and are greater than given in the approximate location for the canal for the purposes of estimating the cost. One-half the surveying party was dismissed on the 1st of October at Dale City. Returning to Salisbury, the valley of Castleman River was examined instrumentally as far up as Pleucher's Narrows, the site of one of the reservoirs proposed in connection with the summit of the Will's Creek route; and Meadow Run, a tributary of Castleman River, coming in from the east just above Salisbury, was traced for a distance of two miles.

The surveying operations were closed here on the 14th of October, over sixty miles of line having been surveyed and leveled in two and one-half months.

The valley of Castleman River, above Salisbury, is a fine, open, agricultural valley, thickly-settled, but not so rich and well-cultivated as the portion between Salisbury and Meyer's Dale City.

Taking with me two assistants, I made a reconnoissance of the headwaters of the North Branch, examining the river from Fairfax's stone, the southwest boundary-corner of the State of Maryland, to the crossing of the Northwestern Turnpike and Ryan's Glade Run, a distance of some fifteen miles, in which distance the river falls at the rate of 20 feet per mile. Thence to Bloomington, some twenty-eight miles, the fall is between 40 and 50 feet per mile. I had intended making an examination of the Black Water Fork of Cheat River, which is just over the mountain from the North Branch, but a snow storm of eight inches depth on the 20th October prevented the carrying out this intention, and the remaining assistants were dismissed.

The valley of the North Branch is quite favorable for canal construction except in the rapidity of its rise.

During the time of our surveying operations the streams were at their lowest stages, and excellent opportunities were afforded for determining their minimum of supply. Several gauges of Savage River and Piney Run were made; also of Castleman River at Pleucher's Narrows.

Mr. C. L. Fulton, assistant engineer, rendered efficient services as transmit-man and in conduct of the surveying party, and Mr. Fred. W. Frost, civil engineer, was a competent and energetic leveler; and in fact all the gentlemen of the party rendered most efficient services, under untoward circumstances of bad weather, with becoming promptness and energy.

HISTORY OF FORMER SURVEYS.

The first authoritative move toward a system of national internal improvements was made in April, 1824, when Congress passed an act authorizing the President "to cause the necessary surveys, plans, and estimates to be made of the routes of such roads and canals as he may deem of national importance in a commercial or military point of view, or necessary for the transportation of the public mail, and to employ two or more skillful engineers and such officers of the Corps of Engineers as he may think proper to carry this act into effect."

In pursuance of this act, the then Secretary of War, John C. Calhoun, constituted a Board of Engineers, consisting of General Bernard, Corps of Engineers, Lieutenant-Colonel Totten, Corps of Engineers, and John L. Sullivan, civil engineer, who entered at once upon their duties, being assisted by many officers of the Army detailed for this purpose.

The Board made very complete surveys and reports on routes for the Chesapeake and

Ohio Canal, the Ohio and Erie Canal (since known as the Sandy and Beaver Canal) in Ohio; Ohio and Schuylkill Canal, (now the well-known Pennsylvania Canal;) Delaware and Raritan Canal; James River and Kanawha Canal, and many other routes for canals and roads.

The first examinations and surveys of a route for a canal to connect the Chesapeake Bay and the Ohio River, by the valley of the Potomac, on the eastern, and the Youghiogheny and Monongahela Valleys on the western, slopes of the Alleghany Mountains, were made in the summer of 1824, and were chiefly to determine the practicability of the undertaking, and were almost entirely restricted to the examination of the mountain or summit section between Cumberland, on the North Branch of the Potomac, and the junction of Youghiogheny and Castleman Rivers, at Turkey Foot.

The route thus surveyed in 1824 was by the North Branch of the Potomac to the mouth of Savage River, and by Savage River, Crabtree Creek, and a branch of Crabtree Creek to Bear Creek and Deep Creek, and thence by the Youghiogheny to Turkey Foot. That part of the route from Cumberland to the mouth of Savage River was surveyed by Maj. J. J. Abert, Topographical Engineers, and the remaining portion by Capt. William G. McNeill, Topographical Engineers.

The Baltimore and Ohio Railroad now occupies a portion of this route from Cumberland, but in ascending the mountain it diverges to the south, its summit being about eight miles south of the summit of the canal-route.

Several summit-crossings were surveyed, and careful gaugings were made of the streams most available for furnishing water for the summit-level, and an elaborate report was prepared by the Board of Engineers. They considered the route practicable with summit-tunnels from one and a third to five and a half miles in length, although the sum of the lockages between Georgetown and Pittsburg was 3,837 feet, which exceeded anything that up to that time had been deemed feasible. The summit-level was found to be 2,408 feet above tide. It was to be supplied with water by means of large reservoirs to be constructed on the Youghiogheny River, at the point where it is now crossed by the route of the Baltimore and Ohio Railroad.

(See Appendix A.)

During the next year a more careful and detailed survey was made "to determine the route to be recommended, as also to obtain the data necessary to frame a general plan of the work and a preparatory estimate of the expense." The report of this year (1826) was more complete than the former one, and discussed the character and general features of another route—that by the valley of Will's Creek, leading northerly and easterly from Cumberland, and crossing the mountains to the valley of Flaugherly Creek, which empties at Meyer's Mill into Castleman River, a branch of the Youghiogheny River, which it joins at Turkey Foot, near Confluence. The summit-level of this route was placed 440 feet lower than the summit-level of the Deep Creek route, with a tunnel four miles long. The distance by the Will's Creek line is eighteen miles shorter between Cumberland and Turkey Foot than by the Deep Creek line.

The supply of water for the summit-level was to be provided by two reservoirs on Castleman River, the lower one at Forney's Mill, one mile below Salisbury and six miles from the west end of the tunnel-level, and the upper one at Pleucher's farm, about five miles above Salisbury and about six miles above the one at Forney's Mill, with which it was to be connected by a feeder. The water-supply was deemed to be more abundant than on the Deep Creek route.

A survey was also made with a view to connect the reservoirs of the Deep Creek route with those of the Will's Creek route. This would necessitate a feeder of twenty-five miles in length to reach Pleucher's farm, with one tunnel two miles long, and another five miles long and otherwise very expensive. This plan, however, was deemed feasible.

The report of 1826 was remarkable in that it gave a careful analysis of prices and probable costs, based on units of labor, of men and horses, and on the cost of producing lime, procuring stone, doing earth-work, obtaining transportation, &c., and these estimates were given for the separate divisions or sections of the proposed canal.

A carefully-prepared estimate was given in detail for characteristic sections of the work, varying from 300 yards to 15,000 yards in length.

The dimensions of the proposed canal were 48 feet width at top water-line, 33 feet at bottom, and 5 feet depth of water.

The section from Georgetown to Cumberland (one hundred and eighty-six miles) was estimated to cost.....	\$8, 177, 081
From Cumberland to Turkey Foot, (seventy and six-tenths miles)	10, 028, 123
From Turkey Foot to Pittsburg, (eighty-five and one-quarter miles)	4, 170, 224

Giving an estimated total cost of..... 22, 375, 428

This estimate of cost was so much greater than had been anticipated that all intentions of carrying out the enterprise were suspended.

The canal company was, however, granted a charter, and a convention was called to consider the conditions controlling the enterprise, and, among other actions taken, they appointed a committee to revise the estimates of the Board of Internal Improvements. This committee met at Washington in December, 1826, and on the most reliable information they could command, and based upon the cost and contract-prices of similar works then in progress, they estimated the cost of the entire canal from Georgetown to Pittsburg at \$10,000,000. The estimates of the Board were severely criticised as being very erroneous, and the then President of the United States, John Quincy Adams, was influenced to appoint a commission of civil engineers to examine the two sets of estimates and reconcile them. Messrs. James Geddes and Nathan S. Roberts, civil engineers of high repute, were appointed to that duty, and reported in 1828. They made the estimated cost of the canal from Georgetown to Cumberland, on the same scale of dimensions as proposed by General Bernard, \$4,330,992, whereas the Board's estimate for the same service was \$8,177,081. This section was completed in October, 1850, at a cost of \$11,071,176. Augmenting General Bernard's estimate by cost of lands for right of way, engineer expenses, damages, and salaries of officers, there was yet a difference of \$2,067,816 over General Bernard's estimate, an increase of 25 per cent., but it is proper to state that the canal as built from Georgetown to Harper's Ferry, a distance of sixty miles, is 60 feet wide at water-line, 42 feet at bottom, and is 6 feet deep; from Harper's Ferry for a distance of forty-five miles it is 50 feet wide at water-line and 32 feet at the bottom; and thence to Cumberland, seventy-seven and one-half miles, it is 54 feet at top and 30 feet at bottom. The depth throughout its whole length is 6 feet. The locks are 100 feet long, 15 feet wide, with an average lift of 8 feet, and they will pass boats of 120 tons capacity. Some difference should also be allowed in favor of General Bernard's estimate for the increase in the value of money and of labor from 1824 to 1850.

I have been thus particular in reciting the history of these estimates because that portion of them relating to the cost of the canal from Cumberland to Pittsburg must at present be taken to give an approximate cost of the proposed extension of the canal proper, reasonable additions being made to them for right of way, engineering expenses, and salaries, &c.; and it is, therefore, important to show their general correctness.

Messrs. Roberts and Cruger also made a location of the canal from Cumberland to Pittsburg in 1828, following almost exactly the leading features of the plan proposed by the Board of Internal Improvements, as to route, plans for reservoirs, &c., excepting only that they passed the summit by a tunnel from the same point on Bowman's Run to a point on Blue Lick Creek, instead of Flaugherly. Their estimate of the section from Cumberland to Pittsburgh was \$7,732,661, while that of the Board of Engineers was \$14,198,346.

WATER-SUPPLY.

The quantity of water needed to operate the canal is dependent on its character and dimensions, the size and lift of its locks, and the daily tonnage to be accommodated; and if the canal have a summit-level, we must consider its character and the length of canal on each side of the summit, which must be supplied therefrom.

The continual losses by surface evaporation, filtration, absorption, and waste at weirs and aqueducts, must also be supplied. All these sources of loss, except that by evaporation, can be reduced to reasonably small quantities by careful construction.

If we use the dimensions recommended by the Board of Internal Improvements, we get a surface width of 48 feet, and locks 100 feet long, 15 feet wide, and 8 feet lift. These locks are adapted to the use of boats of 120 tons burden. [The average tonnage of the canal-boats now in use on the Chesapeake and Ohio Canal is about 112 tons.]

Boats passing alternately up and down through the locks can be passed at the rate of one boat in each eight minutes, or, say, seven per hour, or one hundred and sixty-eight per day of twenty-four hours, which is equal to a daily tonnage of 20,160 tons, or an annual tonnage of 6,148,800 tons for ten months of the year, the probable navigable season on this route. [The greatest number of boats passed through one lock in one day on the Erie Canal was 170 in 1862.]

The summit-level of this route is taken at an elevation of 2,100 feet above tide. Cumberland has an elevation of 603 feet, and the mouth of Savage River 960 feet above tide, while the Castleman River, at the mouth of Piney Run, has an elevation of 1,990 feet above tide.

Castleman River is a large stream amply sufficient to feed the canal westward from the summit. The ascent from the mouth of Savage River to the summit is at the rate of 65 feet per mile, and the tunnel is designed to pierce the mountains at an elevation about 100 feet higher than the mouth of Piney Run. There is not a sufficiency of water to feed the canal on the eastern slope of the mountain, above the mouth of Savage River, and a portion of the canal must be supplied from the summit-level.

We will now examine the conditions of loss and supply of the section east of the

summit, with a view to determine how much loss must needs be supplied from the summit-level.

The section from Cumberland to Savage River, thirty-one miles in length, can certainly be supplied from the daily discharge of the North Branch and Savage River. Allowing the daily loss by evaporation, filtration, and absorption and waste at weirs to amount to three inches per day for each square foot of surface, we find a daily loss on this section of 1,964,160 cubic feet, (5,280 by 31 by 48 by $\frac{1}{4}$), 2,273 cubic feet per second. No account has been taken of the leaking and spill at locks, as these quantities may be considered as the same at each lock, and this water merely passes from one level to another in the same manner as the prism of lift, without loss to the canal.

Several gaugings of Savage River, near its mouth, gave an average discharge of 18 cubic feet per second, and north branch was estimated to deliver at least three times as much more, or 54 cubic feet per second, making an available supply of 72 cubic feet per second, or more than three times the estimated quantity required.

These estimated losses of water are taken for a well-made, puddled canal of favorable conditions. A new canal during the first year or two would probably lose twice this quantity per day; and if the canal were occupied by active transportation the agitation caused thereby would slightly increase the loss by evaporation and waste; however, these causes cannot have a maximum effect except when the canal is well filled with water. No account is taken of the lockage at present, because the prism of lift-water passes from level to level like the spill and leakage at the locks. If provision be made for feeding the canal at one or two other points before reaching Cumberland—say at half way—then the loss to be supplied at the mouth of Savage River would be but one-half that stated above, or 982,100 cubic feet, less than 12 cubic feet per second, and only two-thirds of the quantity of water discharged by Savage River alone.

The summit-level is at a distance of sixteen miles from the mouth of Savage River, the ascent being 1,140 feet, and therefore requiring 143 locks of 8-foot lift, or 114 locks of 10-foot lift.

The daily loss from evaporation on this section would, in accordance with the above data, be less than 12 cubic feet per second. There is no other available constant supply of water east of the summit for this section than the Savage River, which in August last gauged but 6 cubic feet per second at the mouth of Blue Lick. To supply the remaining 6 cubic feet per second—518,400 cubic feet per day—during the months of July, August, and September, will require a reservoir-capacity of about 52,600,000 cubic feet, including a loss by evaporation of one-quarter of an inch per day on reservoirs of 15 feet depth, without regard to either steady or periodical influx during that time. The available places for reservoirs are the valleys of Crabtree Creek, Monroe Run, Poplar Lick Run, and the Savage River, above the mouth of Blue Lick Run. Allotting one-fifth of this quantity (say 10,500,000 cubic feet) to each of the three first-named places, we find that these reservoirs must be 1,800 feet long, 500 feet wide, and must average 12 feet in depth. Allotting to the Savage River the remaining two-fifths of the quantity to be stored, or 21,000,000 cubic feet, we must provide a reservoir 2,500 feet long by 560 feet wide, averaging 15 feet in depth. This can readily be done. A much larger reservoir can be provided on the Upper Savage than is herein required, the valley being very favorable in its topography, as was developed by our survey. That these reservoirs would be filled in the spring months is beyond doubt, as an influx of 4 cubic feet per second would fill either of the smaller ones in thirty days, and the larger one in double that time; and all these streams deliver from 10 to 20 cubic feet per second in March or April, when the snows are melting; while only two-fifths of a cubic foot per second is needed to replace the evaporation on one of the smaller reservoirs.

We come now to consider the summit-level with a tunnel of five miles in length, and a basin at each end one-half a mile long and 32 feet wide, the tunnel itself having 32 feet width of water. The evaporation in the tunnel may be taken as nothing, as in fact there is always an infiltration at tunnels that may be utilized in this case, and assuming that the tunnel may be brick-lined, we need only consider the loss by evaporation, &c., on the two basins, or open portions, and that by leakage and spill at the locks at each end of this level. The latter may be taken at 1,000 cubic feet per hour at each lock. Assuming, as before, the daily loss by evaporation, absorption, and filtration at 3 inches of depth per day, we obtain for one mile of canal a loss of 42,240 cubic feet per day, which, increased by 48,000 cubic feet for loss at locks, gives a total waste on the summit-level of 90,240 cubic feet per day. But the loss from evaporation, &c., between the tunnel and the mouth of Piney Run on the west, and the mouth of Blue Lick on the east, a total distance of nine and a half miles, must also be supplied from the summit-level, and this causes an additional daily loss of 601,920 cubic feet, making a total daily loss, which must be made good, of 692,160 cubic feet per day.

To determine the quantity of water drawn from the summit-level by lockage, we must assume that a certain number of boats will pass the summit daily. If boats follow each other in the same direction over a summit-level, each will take from this level two lockfuls of water; but if they alternate uniformly, boat with boat, then each

boat draws off but one lockful of water. For the purposes of this estimate, we will assume that two-thirds of the boats passing daily are going in the same direction, and the other third in the contrary direction, and thus each boat may be charged as drawing off one and a half lockfuls each, equal to 18,000 cubic feet.

We will for the present consider the daily tonnage to equal 100 boats per day, requiring 1,800,000 cubic feet of water for lockage daily, to which add the daily loss from evaporation, absorption, filtration, and leakage heretofore found, (672,160 cubic feet,) and we have a total daily loss on the summit-level of 2,492,160 cubic feet, or 28.8 cubic feet per second.

The only available source of supply for feeding this summit-level is Castleman River, into whose valley the tunnel opens. The elevation of the summit-level has been taken with special reference to obtaining the necessary feed-water from the Pleucher reservoir on Castleman River, which was originally designed for the Will's Creek route. The average supply or discharge of the river is greater than the quantity required, as the following gauging will show:

	Cubic feet.
June 21, 1825, at Pleucher's, per second.....	18
July 10, 1825, below Flagherty, per second.....	38
July 12, 1825, mouth Flagherty, per second.....	46
March 21, 1825, at Pleucher's, per second.....	93
March 21, 1825, below mouth of Piney, per second.....	536

At the time of our survey a gauging of the river at Pleucher's Narrows gave 25 cubic feet per second.

Taking the same capacity of reservoirs as that proposed by the Board of Internal Improvements, namely, 126,333,780 cubic feet, this amount would be furnished in fifteen days, according to the gauging of March 21. If we assume that only half of this daily supply could be expected, we yet find that the reservoir could be filled in any one of the spring months.

This reservoir was stated to have a surface-area of 9,365,400 square feet, from which the daily evaporation, at a rate of one-fourth of an inch per day, would be 195,120 cubic feet, giving the total daily consumption and loss as follows:

	Cubic feet.
Lockage of 100 boats.....	1,800,000
Evaporation, &c., summit-level.....	90,240
Evaporation, &c., on $9\frac{1}{4}$ miles of canal.....	601,920
Total daily consumption.....	2,552,160

This is at the average rate of 31 cubic feet per second. It may be safely assumed that this daily consumption would be met by the average daily discharge of the river, except during the months of July, August, and September, but during these months the natural flow, at a rate of 18 cubic feet per second, the lowest gauging given would put into the reservoir 1,555,200 cubic feet per day, leaving only 1,133,440 cubic feet to be supplied from the previous accumulations. At this rate the reservoir would not be emptied in less than one hundred and eleven days, or in four months less nine days, even if there should be no rain-fall during the months named.

In addition to this supply, a reservoir is practicable on Meadow Run, and another, of a probable capacity of 25,000,000 cubic feet, on Piney Run, which has a supply of 3 feet per second at Findlay's Mill during the average summer discharge. Assuming for the Meadow Creek reservoir an equal capacity and a depth of 10 feet in each, the loss by evaporation would be for both 104,200 cubic feet per day, and the influx (allowing only 2 feet per second for Meadow Run) 432,000 cubic feet per day.

The Meadow Run feeder would probably be about one mile in length, and the Piney Run feeder about three and one-half miles. Assuming each feeder to have a width of 20 feet, we thus have a total feeder-surface for these two reservoirs of four and one-half miles in length and 20 feet in width. According to our previous allowance of 3 inches vertical on each square foot for losses by all causes, we have a total daily loss on these two feeders of 118,800 cubic feet.

We would thus have a storage-capacity of 176,333,780 cubic feet, and a daily flow into the reservoirs of 1,967,200 cubic feet. On the other hand, we have a daily consumption on the canal of 2,552,160 cubic feet, and a daily loss on reservoirs and feeders of 418,120 cubic feet. The daily drain on the supply stored would therefore be 1,013,080 cubic feet, which would not exhaust them in less than 174 days, or about six months. If the total influx were but $12\frac{1}{4}$ cubic feet per second, the reservoir would last 92 days, even should the canal be worked to its maximum capacity throughout the driest season of the year, conditions that seldom occur and act conjointly for the whole season of the three dry months. Any less amount of business than has been assumed, (equal to 3,600,000 tons during a navigation season of ten months, and the tonnage of the Erie Canal is given as 3,562,500 tons for 1872,) or any rain-fall during

the months named, renders more certain the adequacy of the supply; and only the careless construction of the canal and its appurtenances, or an increase of business over that supposed, or a more protracted drought than has ever been known in this region, can render the supply inadequate.

The data used for evaporation, absorption, and filtration and waste, are the averages of the best authorities, and they are 50 per cent. greater than are taken for the canals of Great Britain.

If we consider the summit-supply as dependent on the average annual rain-fall and the catchment-basins, we find that the catchment-basin of the Pleucher reservoir is very nearly twelve miles long and five miles wide, and has an area of sixty square miles. The average annual rain-fall at Pittsburg, Pa., was 34.96 inches for eighteen years; at Marietta, Ohio, 41.58 inches for twenty-eight years; at Portsmouth, Ohio, 33.20 inches for fifteen years; at Carlisle, Pa., 34.00 inches for six years; and at Gettysburg, Pa., 38.80 inches for seven years. If we take an average of these as representing the annual rain-fall for the region under consideration, we get 38 inches per annum. Applying this to the catchment-area given, and assuming that but one-third of the quantity is caught by the reservoir, we have an annual quantity of 1,698,965,300 cubic feet, enough to fill the reservoir thirteen times; and the Piney Run reservoir, with a catchment-area of twelve square miles, would also be filled thirteen times; the total annual supply by rain-fall being 2,038,758,360 cubic feet, which gives an adequate supply for the use of the canal during a period of twenty-five months, with allowances for evaporation of reservoirs and loss in feeding.

Again, if we take an average of the gauging in March and June as representing the available rain-fall that will be caught by the Pleucher reservoir, we get 1,829,088,000 cubic feet as the annual supply; whereas the consumption for the uses of the canal would be for ten months 780,000,000 cubic feet, or only about 43 per cent. of the estimated supply. This estimate of consumption is twice as great as that assumed by the Board of Internal Improvements.

The changed conditions with reference to the Forney's Mill reservoir, considered essential to the supply of water for the Will's Creek route, renders it of doubtful present practicability. Its site is at the mouth of Piney Run, with a dam one-quarter of a mile below, and the height proposed would raise the water to a contour-line 30 feet above the present surface of the mill-dam at that place; would reach nearly one-fourth the distance to Pleucher's Narrows, and nearly a half mile up Piney Run; would flood the road from Salisbury toward Meyer's Dale City for a distance of half a mile, and would submerge the bridge of Livengood's Mill, and the one at the mouth of Piney Run; it would also cover the road and bridge toward Grantsville, about one mile of a graded railroad, to a depth of from 10 to 20 feet, two mills now in operation, a large area of valuable meadow farming-land, and a part of the surveyed site of the town of Salisbury.

A low dam now in use on this site, if made tight, would save the water-supply for feeding the canal below the mouth of Piney Run.

I have personally examined Castleman River to some distance above Pleucher's Narrows, and find that a reservoir of considerable capacity may be constructed at the crossing of the National road, about two miles above Pleucher's. That would be a very useful auxiliary for storing water for the summit-level, saving a portion of the drainage that in spring floods would waste over the Pleucher dam.

There is yet another source of supply for the summit-level on the Upper Savage at the crossing of the Lonaconing road, where the elevation of the stream is 2,180 feet at the distance of five and a half miles from the mouth of Blue Lick. The topography is very favorable for a large reservoir—say of a capacity of 80,000,000 cubic feet. Thus the summit supply would be increased by nearly 50 per cent., and furthermore provide an ample supply to replace the loss by evaporation on the fourteen-mile section from the summit-level to the mouth of Savage River. If reasonable expense were incurred in puddling or lining the feeders, with a view to reduce the loss in transmission of supply to a minimum, the supply of water would be sufficient for the most active business of the canal.

The tunnel enters the valley of Castleman immediately at the Pleucher reservoir, and there would not be any loss on feeding therefrom, but the feeders from Meadow Run and Piney Run, if brought to the summit-level, should probably be lined, but if fed into the canal at shorter distances they would not need to be lined.

ESTIMATE OF COST.

In making this estimate of cost I have adhered to the dimensions recommended by the Board of Internal Improvements in their report of 1826, viz: 48 feet width at water-line; 33 feet width at bottom, and 5 feet depth of water; locks 100 feet long, 15 feet wide, and of 8 feet lift; because reference must be had to the quantities of work to be done as estimated by them between Cumberland and the mouth of Savage River, and

from Meyer's Mill to Pittsburg. These dimensions are very nearly the same as those of the completed canal between Harper's Ferry and Cumberland, a distance of one hundred and twenty-five miles, equal to two-thirds of the length of the finished canal.

Section from Cumberland to mouth of Savage River, length thirty-one miles, lockage 334 feet.

1,336,600 cubic yards excavation, earth, at 30 cents per yard	\$400,980
300,000 cubic yards excavation, rock, at \$1.25 per yard	375,000
1,300,000 cubic yards embankment, at 20 cents	260,000
200,000 cubic yards retaining wall, at \$1.50	300,000
270,000 cubic yards puddling, at 10 cents extra	27,000
40 culverts, (arches,) at \$2,000 each	80,000
42 locks, 8 feet lift, at \$15,000 each	630,000
2 aqueducts, 120 feet and 210 feet, (wooden)	10,500
1,000 cubic yards aqueduct masonry, at \$10	10,000
4 waste-weirs, \$3,000 each	12,000
30 farm-bridges, at \$450	13,500
5 miles grubbing and clearing	1,250
3 dams, at \$3,000 each	9,000
400 acres land-damages, at \$50	20,000
Special damages, water-powers	15,000
Engineering and superintendence	75,000
Sum of items	2,239,230
Contingencies, 10 per cent	223,923
Cost of thirty-one miles, averaging \$79,456.55	2,463,153

These quantities are made from a comparison of those of the Board of Internal Improvements, and those of Messrs. Roberts and Cruger. Adding the items of farm-bridges, waste-weirs, land and special damages, and engineering superintendence, growing out of the changed conditions of then and now, the average cost per mile of this section, by the Board of Internal Improvements, was \$59,476.

From the mouth of Savage River to Crabtree Creek, distance five and a half miles, lockage 388 feet.

150,000 cubic yards excavation, earth, at 30 cents	\$45,000
50,000 cubic yards excavation, rock, at \$1.20	60,000
80,000 cubic yards embankment, at 20 cents	16,000
10,560 cubic yards retaining wall, at \$1.50	15,840
40,000 cubic yards puddling, at 10 cents extra	4,000
3 culverts, at \$1,500 each	4,500
48 locks, at \$13,500 each	648,000
1 aqueduct	3,000
900 cubic yards masonry, at \$8	7,200
5 miles grubbing and clearing, at \$300	1,500
Dam and feeder, Crabtree Creek	15,000
2 dams	3,000
Engineering and superintendence	12,500
Sum of items	835,540
Contingencies, 10 per cent	83,554
Cost of 5½ miles, averaging \$167,108	919,094

The rock-excitation on this section is a sandstone stratum, and more cheaply worked and being of a quality suitable for the required masonry, and close at hand, the masonry can be more cheaply done. The average cost is great; but there are nine locks per mile, making more than 70 per cent. of the cost.

From Crabtree Creek to summit-level, distance eleven miles, lockage 732 feet.

800,000 cubic yards excavation, earth, at 30 cents	\$240,000
400,000 cubic yards embankment, at 20 cents	80,000
140,000 cubic yards puddling, at 10 cents extra	14,000
10 culverts, at \$1,500 each	15,000
92 locks, at \$13,500 each	1,242,000
10 miles grubbing and clearing	2,500

5 crossing-bridges, at \$450	\$2, 250
5,000 cubic yards protection, at \$1.25	6, 250
2 reservoirs and feeders	20, 000
1 reservoir and feeder	15, 000
Engineering and superintendence	25, 000

Sum of items	1, 662, 000
Contingencies, 10 per cent	166, 200

Cost of 11 miles, averaging \$166,200	1, 828, 200
---	-------------

On this section ninety-two locks make two-thirds of its cost. The reservoirs for Monroe Run, Poplar Lick, and the Upper Savage are included.

Summit-level, six and a half miles long.

This level comprises a tunnel five miles long and approach-basins each three-quarters of a mile long. The dimensions of the tunnel are given by a segmental circular section of 32 feet diameter, with a height of 26 feet from bottom of tunnel to crown of arch, providing a waste-way 25 feet on bottom, 6 feet deep, and 32 feet on top, and a head-way of 20 feet; the lining to be of the best hard brick, with a thickness of 18 inches all around the section. Horizontal fenders are to be laid at water-line, to act as fenders for passing boats and to protect the brick-masonry from injury. The approaches are to give a top water-line of 32 feet and a bottom width of 25 feet, (in rock-cutting.)

No provision is made for a tow-path, because the additional cost of doing so, say \$500,000, would, at 7 per cent. interest, maintain and operate five tug-boats, enough for the business of 100 boats per day.

870,000 cubic yards excavation, tunnel, at \$5	\$4, 350, 000
2,500 cubic yards excavation, shafts, at \$5	12, 500
81,000,000 brick, lining of tunnel, at \$25 per thousand	2, 025, 000
600,000 brick, lining of shafts, at \$25 per thousand	15, 000
180,000 feet (board-measure) fenders, at \$30 per thousand	5, 640
200,000 cubic yards rock-excavation, approaches, at \$1.25	250, 000
20,000 cubic yards concrete filling about arch, at \$10	200, 000
10,000 cubic yards puddling, at 30 cents	3, 000
44,000 cubic yards filling on top of arch, at \$1	44, 000
Engineering and superintendence, 5 years	50, 000

Sum of items	6, 955, 140
Contingencies, 20 per cent	1, 391, 028

Cost of summit-level	8, 346, 168
----------------------------	-------------

From summit-level to the mouth of Piney, five and a quarter miles.

300,000 cubic yards excavation, earth, at 30 cents	\$90, 000
50,000 cubic yards excavation, rock, at \$1.25	62, 500
200,000 cubic yards embankment, at 20 cents	40, 000
60,000 cubic yards puddling, at 10 cents extra	6, 000
8 culverts, at \$1,500 each	12, 000
1 aqueduct over Piney Run	5, 000
16 locks, at \$15,000 each	240, 000
450 cubic yards abutment-masonry, at \$8	3, 600
Grubbing and clearing	600
6 bridge-crossings, at \$450	2, 700
Land-damages	10, 000
Engineering and superintendence	10, 000

Sum of items	482, 400
Contingencies, 10 per cent	48, 240

Cost of 6½ miles, (averaging \$81,636.90)	530, 640
---	----------

From mouth of Piney to Meyer's Mill, six and a quarter miles.

200,000 cubic yards excavation, earth, at 30 cents	\$60, 000
30,000 cubic yards excavation, rock, at \$1.50	45, 000

500,000 cubic yards embankment, at 20 cents	\$100,000
50,000 cubic yards puddling, at 10 cents extra	5,000
3,000 cubic yards protection, at \$1.25	3,750
6 locks, at \$15,000 each	90,000
8 culverts, at \$1,500	12,000
10 crossing-bridges, at \$450 each	4,500
Grubbing and clearing	300
1 aqueduct for Elk Lick	4,500
Repairing dam at mouth of Piney, &c	5,000
1 waste-weir	1,500
Land-damage, 100 acres, at \$100	10,000
450 cubic yards abutment-masonry, at \$8	3,600
Engineering and superintendence	15,000
Sums of items	360,000
Contingencies, 10 per cent	36,000
Cost of 5½ miles, averaging \$72,000	396,000

Pleucher reservoir and feeder.

Dam with regulating and outlet pipes	\$35,000
Meadow and Piney Run reservoirs and feeders	60,000
Sum of items, summit feeders	95,000

From Meyers' Mills to the vicinity of Connellsville the Board of Internal Improvements considered the work in three characteristic sections.

The first section west from Meyers' Mills of sixteen and one-eighth miles, with 216 feet of lockage and 27 locks, was estimated to cost \$1,240,216, averaging \$76,912.62 per mile. Deducting therefrom one and one-eighth miles from the Summit-level to the valley, where our line would join theirs, we get thus:

1st section, fifteen miles, 192 feet lockage	\$1,163,304
2d section, nineteen and six-tenths miles, 420 feet lockage	1,459,317
3d section, twenty-seven and one-half miles, 432 feet lockage	1,515,437
Meyers' Mills to Connellsville, sixty-two miles	4,138,058
Increasing this estimate at the rate of 25 per cent. as found to apply to the section between Cumberland and Savage River	1,034,515
Sum representing estimate	5,172,573
Contingencies, 10 per cent	517,257
Cost of sixty-two miles, averaging \$91,771.45	5,689,830

I have carried the estimate as far as Connellsville for the reason that I am informed that a company has been formed and incorporated by the State of Pennsylvania for the purpose of establishing slack-water navigation as far east on this line as Connellsville, or Ohio Pile Falls; and the section from Cumberland to Connellsville represents fairly the extent of canal needed to be provided to complete the water-line to Pittsburgh.

The recapitulation is as follows:

Cumberland to Savage River, 31 miles	\$2,463,153
Mouth of Savage to Crabtree, 5½ miles	919,094
Crabtree to Summit, 11 miles	1,823,200
Summit-level and tunnel, 6¼ miles	8,346,169
Summit to mouth of Piney, 5½ miles	530,640
Piney to Meyers' Mills, 6¼ miles	396,000
Reservoirs and feeders, (Summit)	95,000
Meyers' Mills to Connellsville, 62 miles	5,689,830
Cumberland to Connellsville, 127¼ miles, averaging \$158,887 per mile	20,268,065

Comparing this estimate of cost with that of the Board of Internal Improvements for the same section of route between the same places, we have from their estimate:

Cumberland to Summit-level	\$3,856,624
Summit-level	3,471,967

Summit to mouth of Castleman.....	\$2, 699, 532
Castleman to Connellsville.....	1, 515, 437
Total, including reservoirs and feeders.....	11, 543, 560
If the tunnel and approaches had been taken of the same dimensions as for the Savage River route, they would have added.....	650, 000
Making a total of.....	12, 193, 560
Adding 25 per cent., as before.....	3, 048, 390
We have.....	15, 241, 950
Contingencies, 10 per cent.....	1, 524, 195

Cost of ninety-eight miles, averaging \$171,083.11..... 16, 766, 145
 Showing an average of \$12,739 more per mile than by our estimate.

The difference between the two estimates of \$3,501,890, if reduced by the cost of the increased number of locks and greater length of tunnel on the Savage River route, will be but \$2,003,000, reducing the average cost per mile to \$147,207, indicating the more favorable character of the route in regard to cost of construction, as was stated in the description of the character of the route.

If, in further comparison of the Will's Creek and Savage River routes with reference to their costs now, we take into consideration that the Will's Creek route between Cumberland and Meyers' Mills is occupied by a railroad in operation holding almost the very ground on which the canal was located, in a valley of which a great portion is not wide enough for two such works, and wherein the canal would necessarily have to be located across the railroad several times under the most unfavorable conditions, and with a second railroad between Cumberland and Little Will's Creek, a distance of fifteen miles, the present recast of the former estimate would fall far short of the extraordinary expenses that are contingent upon the above conditions. It may be affirmed of the Savage River route that "*it would not cost more than the Will's Creek route.*"

The tunnel on the Deep Creek route was planned for a length of one and one-third miles, but the western deep-cut approach would be *five and one-quarter miles long.*

The quantities given in this estimate of cost are as correct as may be, without a more detailed survey and a definite location. The line of the proposed tunnel could not be surveyed to determine its precise length, nor the character of the approaches thereto, nor the location and depth of shafts, all which were determined from the preliminary survey. It is but a reasonable presumption that a careful study of the ground would indicate a somewhat shorter tunnel by correction of chaining and plat, and indicate favorable places for the approaches thereto, that would reduce the estimate of cost.

The strata that would be pierced by the tunnel are inclined at angles of 15° to 20°, are carboniferous, and contain a portion of the "*lower coal-measures*," as described in Professor Lesley's report. The unfavorable condition of the pierced strata would necessitate the lining of the water-section of the tunnel to preserve the summit feed-water.

The tunnel is presumed to be operated by steam-tugs, for the reason that a sufficient number of them can be maintained and operated to accommodate the presumed business of the canal at a cost far less than the interest on the cost of increasing the size of the tunnel, so as to provide it with towing-paths; it is, however, wide enough to be operated in both directions at the same time, as it was thought that the delays in operating a long tunnel only wide enough for one boat would be very burdensome to business. Assuming a speed of three miles per hour through the tunnel, boats arriving shortly after a convoy had started through would be detained nearly four hours, and while waiting, if the season were a busy one, boats would rapidly accumulate until there would be more than could be taken through in one convoy, and a blockade that could not be remedied would be formed; in the same manner a narrow tunnel with a tow-path would cause a still more serious obstruction to business, as a convoy would consume at least three hours in passing through the tunnel, and thus there would be greater delays and unavoidable blockades. If steam should be brought to supersede horse-power on the canal, the tunnel would be favorably conditioned for accommodating the maximum traffic that could pass through other portions of the canal.

The tunnel could be operated with an endless chain, or wire rope, worked by stationary machinery, or by pneumatic tubes fixed on the sides of the tunnel in connection with fixed engines, so arranged as to tow single boats at from four to six miles per hour.

The present state of the enterprise does not warrant an investigation of these suggestions.

An examination has been begun to determine the conditions governing the introduction of inclined planes as substitutes for locks, their economic value as to cost, and economy of time, and water-supply, and their applicability for carrying canal-transit routes over high mountain-ranges.

COMMERCIAL IMPORTANCE.

Of the importance to be attached to the extension of the Chesapeake and Ohio Canal as one of the water-lines of transportation between the Atlantic seaboard and the great cereal-producing region of the great Mississippi Valley, nothing can be added to the volumes that have been devoted to that subject since Washington first interested himself in the scheme of improving the navigation of the Potomac River, with the ultimate purpose of bringing the products of the then West to the seaboard by this route.

The unparalleled development of the great West into a dense population of agriculturists and collaborators renders the necessity of extension of this route urgent, and the condition of monopolies controlling the transportation of the products of the West, establishing the condition of middlemen between the consumers and producers at a ruinous cost, brings about the clamorous demands for its early completion.

The products of the region referred to may be stated at 40,000,000 tons, of which 25,000,000 tons, at least, are destined for market. The capacities for carrying this eastward are as follows, based upon the work done by the routes named :

The Erie Canal carries in one year, tons	2, 640, 000
The Erie Railway, tons	895, 000
The Pennsylvania Railroad, tons	890, 000
The Baltimore and Ohio Railroad, tons	600, 000
The New York Central Railroad	1, 200, 000
The other railway lines, say, tons	500, 000
Total	6, 715, 000

Showing that only about one-fourth of the products seeking a market come direct to the East, and that more than one-third seeks the cheapness of the water-line.

The necessity and utility of additional cheap water-lines of transportation are apparent. Further illustration of the utility of this route as a through line of transportation is uncalled for, in view of the forthcoming report of the United States Senate committee on lines of transportation ; but the local interests dependent on the *extension* of this route are worthy of special consideration.

The first consideration is the further development of the valley of the North Branch of the Potomac River above Cumberland and its several tributaries, in the progress of which the low rates of transportation by canal as compared with railroads are of the first importance.

The second important consideration is the establishment of canal transportation to the Cumberland coal-basin at Piedmont, twenty-eight miles beyond and west of Cumberland, by which convenience the cost of coal to the sea-coast market should be reduced by \$1.65 per ton on present rates by railroads, and a dollar per ton on present combined rates on railroad and canal.

As a third consideration, there are extensive beds of the *lower coal-series*, described in the appended report of Professor Lesley, (Appendix B,) on the North Branch, from the mouth of Savage River to its headwaters, a length of some thirty miles, and extensive forests of the finest of timber, both on the North Branch and the Savage river, already in demand, and now taken to market under great disadvantages and at heavy cost.

But the most important feature, and the one promising the greatest benefit, one that will soon be demanded as a great necessity for the extension, is the fact that the Savage River route traverses the very valuable and extensive *Salisbury coal-basin*, which by calculation contains 90,000,000 tons of coal that can be brought to market out of a deposit estimated at 154,000,000 tons, lying above the beds of the Castleman River, at the place where this route enters the valley. The quantity available from the *lower coal-series*, lying below the bed of the river, is estimated at 90,000,000 tons out of a deposit of 120,000,000 tons. The upper beds can be worked by galleries and adits nearly horizontal, are readily drained, and are identical with the great Pittsburgh, Sewickly, and Cumberland beds, and of same general quality.

Late estimates of the quantity of coal remaining of the great vein of the Cumberland basin give, for 1869, 112,000,000 tons. This basin is being exhausted at the rate of 2,000,000 tons per annum, increasing at the rate of 5 per cent. each year, and at this rate will be exhausted in about twenty years ; and the next available coal-field is the Salisbury basin, only some twenty miles more distant from the eastern markets, and yet within economic distance.

The Cumberland coal is now taxed by railroad freights \$3.16 per ton per two hundred and twelve miles, quite nearly one and a half cents per ton per mile. This coal could be brought to the seaboard by canal for \$1.06 per ton exclusive of tolls, which would be in full business, say 30 cents per ton, a total of \$1.36 per ton, a saving to the consumer of \$1.80 on present prices, or nearly 36 per cent.

The Salisbury beds are opened in several places, and a railroad is graded to connect with the Baltimore and Pittsburgh line. The Keystone Coal Company are mining

and putting coal on the Baltimore and Pittsburgh Railroad by a narrow-gauge line at the rate of 150 tons per day; but the railroad monopoly obstructs the getting of the products of this coal-basin to market, and retards and delays the operations of mining; and consequently the Cumberland Coal Companies avoid competition; all which reacts on the prices at the eastern coal-markets, to the great disadvantage of all classes of consumers, domestic and productive.

For a faithful and full report on the Salisbury coal-basin with regard to quantity, quality, and geological identity, I am enabled to refer to the accompanying report of Prof. J. P. Lesley, for the use of which I am indebted to the courtesy of Mr. John Anspach, president of the Salisbury and Baltimore Railroad and Coal Company; I am also indebted to Mr. Frank T. Wilson, engineer for the company, for valuable information and professional courtesies.

That the lower coal-series can be extensively worked on the north branch above the mouth of Savage River is without question, as many places are opened to veins of 6 and 8 feet thickness, and even of greater thickness, near the head of that stream.

The importance of this extension is also apparent in regard to reaching the several coal-fields of the Youghiogheny, referred to in Professor Lesley's report.

Very respectfully,

THOMAS S. SEDGWICK.

Col. WM. E. MERRILL,
Major Engineers, U. S. A.

Appendix A.

REPORT OF THE BOARD OF INTERNAL IMPROVEMENT ON THE CHESAPEAKE AND OHIO CANAL, FEBRUARY 2, 1825.

This canal may be divided in three sections—eastern, middle, and western. The eastern section extends from the tide-water in the Potomac to the mouth of Savage River, in the northern branch of the Potomac. The middle section extends from the mouth of Savage River in the Potomac to that of Bear Creek in the Youghiogheny. The western section from the mouth of Bear Creek to the Ohio at Pittsburgh.

EASTERN SECTION.

[As this section has been built, all matters relating to it are omitted.]

MIDDLE SECTION.

This section, from the mouth of Savage River in the north branch of the Potomac, extends to the mouth of Bear Creek, in the Youghiogheny, on the west side of the Alleghanies. It includes the summit-level of the canal, and from the complicated topography of the ground, the height which must be overcome in a short space, and the difficulty of securing a sufficient supply of water in dry seasons at such an elevation, presents the greatest difficulties which occur in the whole project.

The Little Back Bone Ridge divides the waters, which, in that part of the Alleghanies, runs east and west; it runs parallel to the Great Back Bone, through which Savage River forces its way, and the canal must absolutely pass through this gap. Between those two ridges run Crabtree Creek, from southwest to northeast, and Savage River from northwest to southeast, the former falling into Savage River four and a half miles above its mouth in the Potomac. From the west side of the Little Back Bone falls Deep Creek and the Little Youghiogheny; the latter runs from east to west, and, after forcing its way successively through Hoop-pole Ridge and Roman Nose Ridge, joins the Great Youghiogheny. Deep Creek runs at first to the north, crossing Hoop-pole Ridge and Negro Mountain; then, intercepted by Marsh Mountain, it turns west and falls into the Youghiogheny. The gap through which it forces its way across the Hoop-pole Ridge is only sixty-six yards wide, and is called the Narrows.

The heads of the Little and Great Youghiogheny, to some miles above the point where they join in a single stream, run through marshy meadows known by the name of glades. The valleys of Deep Creek and its tributaries offer the same features as low down as Marsh Mountain, from whence their course continues in a deep and narrow ravine, with steep and rugged banks. The bottom of these glades, which has been sounded in several places, presents the following layers: first, rich loam; second, sand, colored by oxydated iron; third, vegetable detritics; fourth, alluvial clay; fifth, a horizontal bank of sandstone, 4 or 5 feet below the surface, on which the other layers all lie.

The Great Youghiogheny, after receiving the Little Youghiogheny and Deep Creek, receives Bear Creek. The east branch of this last stream rises on the west side of Negro Mountain, and runs from south to north till it forces its way through Keyser's Ridge; it then runs suddenly west, and, after forcing through Winding Ridge, falls into the Youghiogheny. Its west branch springs from the west side of Keyser's Ridge, and joins the other at the gap, where it forces its way through Winding Ridge.

Savage River runs on a bed of sandstone; its course is rapid, and broad flats extend along both its banks. Crabtree Creek is the chief tributary stream which joins it; it runs between the Great and Little Backbone, and is formed by the junction of Crabby's Arm and Wilson's Fork, which take their sources in that part of the Little Backbone which divides their ravines from the valley of the Little Youghiogheny. Crabby's Arm runs in a narrow vale, but which is, however, wide enough to receive a canal; its bottom is a black, alluvial soil, and its banks present a gentle slope. Wilson's Fork is more rapid, but runs in a wide and well-wooded valley. These two streams join at Swan's Mill, from whence they impetuously descend on a bed from ten to twenty yards wide. They are interrupted in two or three places by perpendicular falls, 7 or 8 feet high, and frequently by smaller rapids, which fall from 4 to 5 feet. From the Great Backbone, Crabtree Creek receives several tributaries; they are torrents which fall into it with great impetuosity. On both sides of its valleys run flats eight or ten yards wide, which are intersected by rugged bluffs, from 100 to 200 feet high, which divide them into isolated portions, the bluffs on one side of the stream lying, in general, opposite to the flats on the other, and the two banks presenting an alternate succession of the same features.

Such are the main streams which, in this section, descend from the two sides of the Alleghanies.

To conduct the canal across this summit ground we must, 1st, select the best passage for it through the Little Backbone, by leading it either from the valley of Savage River to that of Deep Creek, and from that of Crabtree Creek to the same, or from the valley of Crabtree Creek to that of the Little Youghiogheny; 2d, ascertain which of these passages presents the shortest route from the mouth of Savage River to that of Bear Creek; 3d, ascertain, as the most essential element of the whole project, whether a supply of water sufficient for all the purposes of the canal can be procured at this elevation.

We shall point out the several passages which lead through the Little Backbone, beginning by those which lead from the valley of Savage River to that of Deep Creek. But, in the first place, it is necessary to state that a base-mark has been fixed on the bridge of Deep Creek, 3 feet above its bottom; to this have been referred all the levels taken on this section of the canal.

Monroe Run, a tributary of Savage River, and Meadow Mountain Run, a tributary of Deep Creek, offer the only ravines through which Deep Creek and Savage River can be connected. For this purpose it will be necessary to run a tunnel through the Little Backbone. Supposing its bed on a level with the base-mark, and a deep cut of 35 feet at each extremity of it, this tunnel would extend five miles 833 $\frac{1}{3}$ yards in length. The greatest elevation of the ridge above the bed of the tunnel would be 213 feet. From its eastern extremity to the mouth of Monroe Run, in Savage River, the descent is 933 feet, on a length of five miles 816 $\frac{2}{3}$ yards. From the mouth of Monroe Run to that of Crabtree Creek, in Savage River, the descent is 109 feet on a length of 2 miles 916 $\frac{2}{3}$ yards. From the mouth of Crabtree Creek to that of Savage River itself, in the Potomac, the descent is 340 feet, on a length of five and one-half miles. The level of the mouth of Savage River lies, of course, 1,432 feet below the base-mark, and at a distance of twenty-one miles 327 yards from it, ascending the ravines of Savage River and Monroe Run, and descending those of Meadow Mountain Run and Deep Creek.

Meadow Mountain Run flows through glades, but Monroe Run falls down a ravine whose upper portion is very steep and narrow; it widens, however, as it descends, and presents a succession of bluffs and flats, which extend to twenty-five yards in breadth. The bluffs hang perpendicularly over the stream. At the mouth of Monroe Run, Savage River is only thirty-three yards wide, and a dam might easily be thrown across to form a reservoir.

This passage is the only one which leads from the valley of Savage River to that of Deep Creek.

We shall now examine those which connect the valley of Crabtree Creek and Deep Creek. The first lies between the middle fork of Crabtree Creek and the Meadow Mountain Run, and would require a tunnel running under the Little Backbone and Hoop-pole Ridge. Supposing its bed on a level with the base-mark, and an open cut to the depth of 35 feet through the height, the tunnel would extend three miles 1,334 yards in length. From its eastern extremity to Crabtree Creek, in following the windings of the middle fork, the descent is 1,012 feet on a distance of six miles 1,333 $\frac{1}{3}$ yards; and from the mouth of the middle fork to the mouth of Savage River, in the Potomac, the descent is 420 feet on a distance of six miles 685 yards. The height of the ridge above the bed of the tunnel would be 210 feet, and the ravine of middle fork diffe

little from that of Monroe Run. Its general breadth is about 27 yards, and its banks are rugged. The whole distance from the base-mark to the mouth of Savage River would be, by this passage, nineteen miles 915 yards.

Three passages run through the Little Backbone from three branches of North Glade Run, a tributary stream of Deep Creek, to the valley of Crabtree Creek.

The first opens on the western branch of the middle fork, and would require a tunnel through the Hoop-pole Ridge. Supposing its bed on a level with the base-mark, and an open cut to the depth of 35 feet through the height, the tunnel would extend three miles $125\frac{1}{2}$ yards in length, and the greatest height of the ridge above its bed would be 144 feet.

From the second branch of North Glade Run a passage might be opened to the eastern branch of the middle fork by a tunnel of the same nature and on the same level as the former. It would extend three miles and 83 yards in length, and the greatest height of the ridge above its bed would be 184 feet. But from its eastern extremity there would be a descent of 280 feet on a distance of one mile 366 yards.

From the third branch a passage might be opened to Rock Camp Run by a tunnel four miles in length. The greatest height of the ridge above its bed would be 222 feet; but from its eastern extremity to Crabtree Creek the descent would be 728 feet on a distance of two miles $166\frac{1}{2}$ yards, and through a very narrow, rugged, and precipitous ravine. The north fork of Deep Creek rises near the summit of the Little Backbone at Whitsall's Springs, 105 feet above the base-mark. The spring of Savage Lick Run, a tributary stream of Crabtree Creek, rises opposite to it. A tunnel which would join them, with its bed on a level with its base-mark, and an open cut through the height at each of its extremities to the depth of 35 feet, would extend two miles 1,083 yards in length. From its eastern extremity to Crabtree Creek the descent would be 452 feet on a distance of two miles and 100 yards, and the greatest height of the ridge above its bed would be 148 feet.

Three more passages have been surveyed between the tributaries of the north fork and those of Crabtree Creek.

The first unites Hinch's Arm to Glade Road Run by a tunnel one mile 1,166 yards in length on a level with the base-mark. The distance from its eastern extremity to Crabtree Creek is 1,500 yards, and the greatest height of the ridge above its bed 205 feet.

The two others unite Dry Arm and Dewickman's Arm with small ravines of Crabby's Arm, a tributary stream of Crabtree Creek, which rise opposite to them. The tunnel which would be required at Dry Arm would extend one mile 916 yards in length, and the greatest height of the ridge above its bed would be 271 feet. The tunnel of Dewickman's Arm would extend one mile $683\frac{1}{2}$ yards in length and the greatest height of the ridge above its bed would be 227 feet. These two tunnels, on a level with the base-mark, are the shortest of those that we have enumerated on any of the designed routes of the canal.

Two passages have been surveyed and leveled to open a communication between Crabtree Creek and the Little Youghiogheny, the one from Crabby's Arm and the other from Wilson's Fork to the latter stream. They would each require a tunnel. Supposing its bed on a level with the base-mark, the tunnel from Crabby's Arm would extend three miles 1,568 yards, and the tunnel from Wilson's Fork four miles 300 yards in length, with an open cut at each of their extremities to the depth of 35 feet. The greatest height of the ridge above the bed of the tunnel from Crabby's Arm would be 444 feet, and above that of Wilson's Fork 253 feet. The distance from their eastern extremities to Swan's Mill would be two miles, with a fall of 114 feet from Swan's Mill to the mouth of Crabtree Creek the descent would be 940 feet on a distance of seven miles 966 yards; from the mouth of Crabtree Creek to that of Savage River, on the Potomac, the distance five miles 880 yards, and the descent 378 feet. Thus from the eastern extremity of the tunnel to the mouth of Savage River the total descent is 1,432 feet on a distance of fifteen miles 86 yards, and of these two tunnels the one by Crabby's Arm is the shortest.

Other passages have also been examined to open communications between Deep Creek and the waters of the Little Youghiogheny. The bed of the tunnels required for this purpose was fixed 17 feet above the level of the base-mark. One of these tunnels join Westlick Run to one of the branches of the South Fork of Deep Creek. Its length was two miles $583\frac{1}{2}$ yards, and it required a deep cut on the side of Westlick Run of the length of one mile 600 yards, and another on the side of South Fork of the length of two miles 50 yards. Another tunnel might join the Little Youghiogheny itself to South Fork. It would extend one mile 1,300 yards in length, and require an open cut of one mile $1,566\frac{1}{2}$ yards in length toward the Little Youghiogheny, and two miles 300 yards toward the South Fork. The height of the ridge above the first tunnel would be 143 feet, and above the second, 183 feet.

Such are the chief passages through which a communication might be opened between the waters which descend from the eastern and western sides of the Little Backbone.

In recapitulating the several routes by which the canal may be directed through them, we will observe that they all extend from the mouth of Savage River, either by the valley of that stream or Crabtree Creek, to the base-mark on the bridge of Deep Creek, and that the descent or fall of the canal by all these routes is 1,432 feet.

1st. The first ascends by Savage River, Monroe Run, Meadow Mountain Run, and Deep Creek. Its total length, from the mouth of Savage River to the base-mark, is twenty-one miles 325 yards. The length of the tunnel which it requires through the ridge is five miles 833½ yards, and the height of the ridge above its bed, 213 feet.

2d. The second ascends by Savage River, Crabtree Creek, Middle Fork, Meadow Mountain Run, and Deep Creek. Its total length is nineteen miles 915 yards. The length of the tunnel which it requires through the ridge is three miles 1,333½ yards, and the height of the ridge above its bed is 210 feet.

3d. The third ascends by Savage River, Crabtree Creek, Middle Fork, the western branch of the same fork, North Glade Run, and Deep Creek. Its total length is twenty miles 1,128 yards; the length of the tunnel which it requires through the ridge, three miles 125 yards, and the height of the ridge above its bed, 144 feet.

4th. The fourth ascends by Savage River, Crabtree Creek, Middle Fork, the eastern branch of the same, North Glade Run, and Deep Creek. Its total length is twenty miles 1,306 yards; the length of the tunnel which it requires through the ridge, three miles 83 yards; the height of the ridge above its bed, 184 feet.

5th. The fifth ascends by Savage River, Crabtree Creek, Rocky Camp Run, North Glade Run, and Deep Creek. Its total length is nineteen miles 630 yards; the length of the tunnel which it requires through the ridge, four miles, and the height of the ridge above its bed, 222 feet.

6th. The sixth ascends by Savage River, Crabtree Creek, Savage Lick Run, North Fork, and Deep Creek. Its total length is twenty-one miles 435 yards; the length of the tunnel which it requires through the ridge, two miles 1,083 yards, and the height of the ridge above its bed, 148 feet.

7th. The seventh ascends by Savage River, Crabtree Creek, Hinch's Arm, Glade Road Run, North Fork, and Deep Creek. Its total length is twenty-one miles 1,158 yards; the length of the tunnel which it requires through the ridge, one mile 1,166 yards, and the height of the ridge above its bed, 205 feet.

8th. The eighth ascends by Savage River, Crabtree Creek, a ravine of Crabby's Arm, Dry Arm, North Fork, and Deep Creek. Its total length is twenty-one miles 1,368 yards; the length of the tunnel which it requires through the ridge, one mile 916 yards; and the height of the ridge above its bed, 271 feet.

9th. The ninth ascends by Savage River, Crabtree Creek, a ravine of Crabby's Arm, Dewickman's Arm, North Fork, and Deep Creek. Its total length is twenty-one miles 718 yards; the length of the tunnel which it requires through the ridge, one mile 663½ yards; and the height of the ridge above its bed, 227 feet.

From the base-mark the localities of the ground leave us a choice between three routes to the mouth of Bear Creek.

The first runs by Deep Creek, Buffalo Marsh Run, Rocklick Run, a tributary stream to the western branch of Bear Creek, that western branch to its mouth in Bear Creek, and Bear Creek itself to the Youghiogheny. This route crosses, by a tunnel, the ridge which divides the heads of the western and eastern branches of Bear Creek. This tunnel beginning at McHenry's, and with an open cut of the depth of 35 feet at its southern extremity, near McHenry's, and at its northern extremity, would extend about two miles in length, and the greatest height of the ridge above its bed, supposed on a level with the base-mark, would be about 170 feet. The whole ground along this route, except where it passes through the gap of Winding Ridge, is of a soft and good quality; and its whole length, from the base-mark to the mouth of Bear Creek, would be only twelve miles.

A second route might turn round the west of Marsh Mountain, and wind about Panther's Point. It would then turn successively round the heads of the ravines of Hoy's Run, Steep Run, Sang Run, Gap Run, and descend along Friend Run, a tributary of the western branch of Bear Creek. This route is very circuitous, and in winding round Panther's Point runs through a rocky and difficult ground. It could only be shortened by running an aqueduct 250 feet high, and above a quarter of a mile long, through the western branch of Hoy's Run, or a tunnel half a mile in length from that western branch to the head of Steep Run. The height of the ridge above the bottom of that tunnel would be about 250 feet. A level was also run over a bend of ground at Hoy's Pine Bottom to endeavor to shorten it and avoid the winding round of Panther's Point, but to run the canal over this line would require a deep cut of 1,431 yards in length, and of the depth of 99.06 feet, at the highest point of the ridge. The total length of this route would be twenty-four miles.

The third route, descending the valley of Deep Creek from the base-mark, might follow the eastern shore of the Youghiogheny to the mouth of Bear Creek, crossing successively on aqueducts Hoy's Run, Steep Run, Sang Run, Gap Run, Bear Creek, and the smaller tributary streams of that river. The ground along this route is rocky

and difficult for one mile and three-quarters from Deep Creek to Hoy's Run; then light and easy for four miles to Gap Run; then rocky for the space of six miles, following the western bank of Winding Ridge; then for two and a quarter miles light and easy to the mouth of Bear Creek. The total length of this route would be twenty miles.

We have not mentioned a fourth route, which, from the base-mark, running by a tunnel through Negro Mountain, might unite Deep Creek with the eastern branch of Bear Creek, because it would require a tunnel of eight miles in length, and that the height of the ridge above its bed would be from 400 to 500 feet in the most elevated portion. The length of this route would also pass twenty miles.

Such are all the routes which lead from the valleys of Savage River and Crabtree Creek, in passing by that of Deep Creek to the mouth of Bear Creek, in the Youghiogheny. We must now examine those which, departing from the head of Crabtree Creek, reach the same point in passing by the valleys of the Little and Great-Youghiogheny.

For this purpose the canal should follow the valley of Savage River from the mouth of that stream, and ascend along Crabtree Creek till it reaches two miles above Swan's Mill, where opens the eastern extremity of the tunnel of Crabby's Arm, mentioned on page 10 as the shortest of those by which Savage River can be connected with the Youghiogheny. Passing through that tunnel it would descend the valleys of the Little and Great Youghiogheny, winding along their eastern sides. When it reaches the mouth of Deep Creek, it may follow one of these three directions:

1st. Ascend Deep Creek and Buffalo Marsh Run, following the first of the three routes which we have just indicated for passing from the base-mark to the mouth of Bear Creek. This route, as we have seen, presents a tunnel two miles in length. The total distance over which it runs is as follows:

	Miles.	Yards.
From the mouth of Savage River to the east extremity of the tunnel of Crabby's Arm	15	86
From thence to the mouth of Deep Creek	22	426
From thence to the mouth of Buffalo Marsh Run	6	...
From thence to the mouth of Bear Creek	11	440

Total distance from the mouth of Savage River to that of Bear Creek.. 54 952

This route would present two tunnels, one three miles 1,538 yards in length at Crabby's Arm, and the other two miles in length between Buffalo Marsh Run and Rocklick Run; total, nearly six miles of tunneling.

2d. The canal might cross Deep Creek and follow the second route indicated for passing from the base-mark to Bear Creek, by winding round Panther's Point, and the heads of the ravines of Hoy's Run, Steep Run, Sang Run, Gap Run, and Friend Run to the western branch of Bear Creek. Its total length would be:

	Miles.	Yards.
From the mouth of Savage River to that of Deep Creek, as above.....	37	512
From thence to Bear Creek	17	660
Total length	54	1,172

This route presents only one tunnel, of the length of three miles 1,538 yards, or nearly four miles, at Crabby's Arm. It may also be shortened, as mentioned above, by an aqueduct one-fourth of a mile in length and 250 feet high, or a tunnel one-half mile in length, with 250 feet of height of ridge above its bed.

3d. The canal might fall on this third route indicated above, after crossing Deep Creek, by keeping along the eastern side of the valley of the Youghiogheny, and crossing its tributaries on aqueducts. Its total length would be as follows:

	Miles.	Yards.
From the mouth of Savage River to that of Deep Creek, as above.....	37	512
From thence to Bear Creek	13	660
Total length	50	1,172

This route would require, like the preceding one, one tunnel, of three miles 1,538 yards, or nearly four miles in length.

From the comparison of these three routes it is evident that the second is preferable to the first. Their length is nearly the same, but the first requires six miles of tunneling and two tunnels, while the second requires only one tunnel, of something less than four miles in length. The third is shorter again, by four miles, than the second, and passes by the same tunnel. Aqueducts must be constructed on this route to cross Hoy's Run, Steep Run, Sang Run, Gap Run, and Bear Creek, but by the successive dropping of its levels they will require but a small elevation, and the waters of these runs and of the Great Youghiogheny may be raised and used to feed the canal, an advan-

tage which the other routes do not offer. It should also be observed that these runs are not above 200 or 300 feet wide at their mouths in the Youghiogheny. The third route is therefore preferable to the two others, on the hypothesis of uniting the mouths of Savage River and Bear Creek through the valleys of the Little and Great Youghiogheny.

We will now compare this route, which we will call the Youghiogheny route, with those which lead from Crabtree Creek to Deep Creek.

Nine routes, which all unite at the base-mark, have, as we have stated before, been examined for this purpose. Their length varies only from nineteen to twenty-two miles, but their tunnels present a much greater difference. The longest extends five miles $83\frac{1}{2}$ yards, or about five and a half miles; and the shortest, one mile $63\frac{1}{2}$ yards, or about one and one-third miles in length. The last should certainly be preferred. Its whole length is twenty-one miles 718 yards; and the greatest height of the ridge above its tunnel is 227 feet. We shall call it Dewickman's Arm route.

We have also observed that there are three routes from the base-mark to the mouth of Bear Creek. The first runs twelve miles, by Buffalo Marsh Run, and Rock Lick Run. It is the shortest, but requires two miles of tunneling. Were it not for this obstacle it offers a favorable ground for digging the canal. The second, winding round Panther's Point and the heads of Hoy's Run, Steep Run, Sang Run, Gap Run, &c., is twenty-four miles long, and is objectionable, not only for its length, but from the difficulties which it presents in turning Panther's Point. The third, by the valleys of Deep Creek and of the eastern bank of the Youghiogheny, is twenty miles long. It is shorter by four miles than the second, and requires no tunneling. In this respect it is superior to the first; for two miles of tunnel costs more than eight miles of canal, which is the difference of their length. The passage of an active trade will also meet with more delay on a tunnel of two miles, unless its dimensions are very large, than on four or six miles of canal. This route possessing, besides, over the two others, the advantage of feeding the canal below the mouth of Deep Creek, by raising the waters of the Great Youghiogheny and its tributaries, is preferable to them in all respects.

If we add the twenty miles of this route to the twenty-one miles 718 yards of Dewickman's Arm route, we shall have for the whole length of the canal, passing along Crabtree Creek, Deep Creek, and the valley of the Youghiogheny, forty-one miles 718 yards, with one tunnel one and a third miles in length, and the height of the ridge above it 227 feet. We shall call this route Deep Creek route, in opposition to the Youghiogheny route.

To decide between these two routes, which alone can enter in competition, we must compare their length, and the time, expense, difficulties, and trouble of their construction, viewed in a general manner.

The length of the Deep Creek route is forty-one miles 718 yards; that of the Youghiogheny route fifty miles 1,172 yards. The former is, therefore, shorter by nine miles than the other.

The tunnel from Dewickman's Arm on the Deep Creek route is one mile $63\frac{1}{2}$ yards in length, and the height of the ridge above its bed is 227 feet. The tunnel between Crabby's Arm and the Little Youghiogheny, on the Youghiogheny route, is three miles 1,538 yards in length, and the height of the ridge above its bed is 464 feet. The former requires two miles 855 $\frac{1}{2}$ yards less of tunneling, and the height of the ridge above the bed of its tunnel is 237 feet less. With respect to the expense of tunneling, the route by Deep Creek is, therefore, preferable to the other.

As to the deep cuts at each extremity of these tunnels, the deep cut at the western extremity of the tunnel, toward the Little Youghiogheny, is two miles 930 yards in length. The deep cut at its eastern extremity, toward Crabby's Arm, is 900 yards. The whole deep cutting on the Youghiogheny route is thus three miles 70 yards.

The deep cut at the western extremity of the other tunnel, toward Deep Creek, extends five miles 1,096 yards. The deep cut at its eastern extremity, toward Dewickman's Arm, 572 yards. Total, five miles 1,668 yards.

The Youghiogheny route will therefore require two miles 1,598 yards less of deep cutting than the other at the extremities of its tunnels. But this advantage is not to be weighed with the expense of two miles 855 yards more of tunneling.

In comparing the nature of the soil on each of these routes and the obstacles which it may present, it must be remembered that their eastern portion, from Savage River to Crabby's Arm, and their western portion, from the mouth of Deep Creek to that of Bear Creek, are the same. In the intermediate space the ground is equally favorable and easy to work on both routes.

On the whole comparison of their respective lengths, of the time necessary to pass through the one or the other of the obstacles which they meet, and the expense and probable trouble of their construction, we believe the Deep Creek route preferable to the route by the Youghiogheny.

Our next task must be to compare the supplies of water which the canal may receive on either of these routes, and this will lead us to a detailed investigation of the re-

sources which are offered by the water-courses of the country to feed the middle section and summit-level of the proposed canal.

Savage River and its tributary, Crabtree Creek, may feed the eastern branch of the middle section, and the great Youghiogheny its western branch. The summit-level must draw its resources from Deep Creek and the heads of the Little and Great Youghiogheny.

These streams were all gauged in 1824 at their lowest stage. We will give, in a general manner, the result of these operations, the minimum, in cubic feet of water, that flows through each stream in a second.

EASTERN BRANCH OF THE MIDDLE SECTION|

Cubic ft.

Savage River gave on the 23th September below the mouth of Crabtree Creek, in a second.....	17.73
Savage River gave on the 28th September at its mouth, (it had, however, rained this day).....	46.09
Savage River gave on the 2d September below Monroe Run.....	28.62
Monroe Run gave on the 28th September at its mouth.....	0.88
Monroe Run gave on the 16th September at its mouth.....	2.28
Crabtree Creek gave on the 14th September at Swan's mill.....	0.97
Middle Fork gave on the 15th September at its mouth in Crabtree Creek.....	0.84
Rock Camp Run gave on the 2d September at its mouth in Crabtree Creek.....	0.12
Savage Lick River gave on the 14th September at its mouth in Crabtree Creek.....	0.33
Crabby's Arm gave on the 17th August at its mouth in Crabtree Creek.....	0.24
Wilson's Fork gave on the 17th August at its mouth in Crabtree Creek.....	0.35

If we consider that the water consumed in the lockage of this branch is supplied from the summit-level, these streams, turned into reservoirs by dams thrown across the tributaries of Crabtree Creek and Savage River, above the mouth of that creek, will serve to supply its losses from filtrations and evaporation. Between the mouth of Crabtree Creek and the Potomac, on a distance of five and one-half miles, Savage River, which gives 17.73 cubic feet in a second at its lowest stage, will serve for this purpose. In the remaining nine and one-half miles from the tunnel to the mouth of Crabtree Creek the Middle Fork gives 0.84 cubic foot; Rock Camp Run, 0.12 cubic foot; Savage Lick Run, 0.33 cubic foot; and Crabtree Creek itself, 0.97 cubic foot, at Swan's mill, at their lowest stages; total, 2.26 cubic feet. Reservoirs may besides be formed in the Middle Fork, Savage Lick Run, and Rock Camp Run. Filtrations may also be prevented, in a great degree, by a careful construction of the bed of the canal; and from observations taken in the summer of 1824 the loss from evaporation did not exceed the quantity received by summer rains. It may also be observed that any deficit will prove to be amply supplied by the waters of the summit-level.

From the mouth of Savage River the canal may be supplied from the North Branch of the Potomac, which, on the 18th September, gave 106 cubic feet in a second; and a great reservoir may be formed in it above the mouth of Savage River. From this point, therefore, it needs no longer the waters of Savage River nor of its tributaries. And if we except the waters required for its lockage, which will be supplied from the summit-level, this branch of the middle section may be fed in a great degree by the streams which fall into it.

WESTERN BRANCH OF THE MIDDLE SECTION.

This portion of the canal begins in Deep Creek, five miles below the base-mark, and ends at the mouth of Bear Creek. Its length is fourteen and three-fourths of a mile, and, like the former branch, it will receive from the summit-level the waters required for its lockage.

Hoy's Run, Steep Run, Sang Run, and Gap Run may be employed to feed it and repair its losses; but these streams have not been gauged. They may, nevertheless, offer some resources for reservoirs. Bear Creek may also form a great reservoir, by damming its valley and feeding the western section of the canal, but cannot feed the western branch of the middle section, from the difference of their levels.

Deep Creek is the only stream of any importance whose waters may supply the losses of this branch from filtrations and evaporation. We should, therefore, examine accurately the means which it offers for this purpose. Its usual depth under the bridge is 3 feet; but in its freshets it rises to 12 feet. High freshets generally occur in this stream twice or thrice a year, and last from three to four days; when the rains last so long, it gives, during that time, from 400 to 500 cubic feet a second. During the most unfavorable season it still has freshets, less considerable, but which, nevertheless, give it a mean discharge about 100 cubic feet in a second each time; these occur from six to eight times a year. In the driest months it gives, under the bridge, from 10 to 54

cubic feet a second; on the 27th August, 1824, it gave 5.12 cubic feet, which was the lowest quantity we ever found.

Supposing a dam erected across Deep Creek at the head of its rapids, and five miles below the base-mark, its basis would be $19\frac{1}{2}$ feet below that mark; its length would be $136\frac{1}{2}$ yards, and to raise its waters 4 feet above the base-mark its height should be 23 $\frac{1}{2}$ feet. This dam would raise the waters of Deep Creek so as to overflow an area of 948,924 square yards, from accurate surveys. The prism of this reservoir, comprised between its surface and a horizontal plane, run 3 feet below the base-mark, would be 7 feet high, and contain in capacity 2,214,156 cubic yards. In less than three months of the rainy season, if we allow only 9 cubic feet, or one-third of a cubic yard a second to the average supply of Deep Creek, this reservoir would be filled. It would be filled in less than five months in summer if the stream yielded at the rate of 5 cubic feet. Thus, every year, and for nine months of navigation, from the middle of March to the middle of December, we may depend on a supply equal to twice the capacity of this basin, or 4,428,312 cubic yards. This is equivalent to 492,034 cubic yards a month, and supposes only a mean supply of $5\frac{1}{2}$ cubic feet a second. This is the minimum of what Deep Creek can supply to repair the losses of the western branch of the middle section from filtrations and evaporation. To ascertain its sufficiency, we must examine next what those losses may amount to.

The length of this section is fourteen and three-quarter miles. Supposing it 5 feet deep, 28 feet broad at the bottom, and 44 feet at the surface of the water, the prism of its capacity will have a base of 20 cubic yards, on a length of fourteen and three-quarter miles, equal to a cube of 519,200 cubic yards. This will be filled in the first days of March without deranging the economy of water which we have just analyzed. We have already observed that Deep Creek may supply every month a cube nearly corresponding to this, or 492,034 cubic yards, at the minimum rate, and lowest stage of its flow; we must now examine whether this supply will suffice every month to the filtrations and evaporation of fourteen and three-quarter miles of canal.

Without entering into minute calculations which properly belong to the report accompanying the final project of the canal, we will state generally the most positive results which experience has given as to the joint amount of filtrations and evaporation. Having ascertained that no experiments of this nature have been tried on the Erie Canal, where the supply of water was found evidently more than sufficient, we were obliged to consult the results of those canals constructed in Europe, under a climate which, in the summer, comes nearest to our own. We have selected for this purpose the canal of Narbonne, in the south of France. Narbonne and Baltimore, compared as to climate and rain, are as follows:

Narbonne, latitude north $43^{\circ} 11'$, (from observations made during twenty years.) Mean greatest heat, 95° ; mean temperature, 60° ; mean greatest cold, 24° ; mean quantity of rain, 29.30 inches.

Baltimore, latitude north $39^{\circ} 17'$, (from observations made 1817-1822, by Mr. Lewis Brantz, of Maryland.) Mean greatest heat, $94^{\circ} 56'$; mean temperature, $52^{\circ} 23'$; mean greatest cold, $0^{\circ} 12'$; mean quantity of rain, 38.60 inches.

Of all such works, the canal of Narbonne has given most trouble to its engineers, from its excessive filtrations and loss of water in the gravelly soil through which it is run. It is a branch from the canal of Languedoc to the city of Narbonne, three miles in length. As soon as it was opened, in 1788, it lost the value or contents of its prism in a few days and overflowed the surrounding country; in 1789 it still lost the value of its prism in six days; and in 1800 it lost it in eighteen days, or the value of its prism and two-thirds every month—sixteen and two-thirds times its contents in ten months' navigation. This evaluation is the result of careful and accurate observations; and, considering the climate and soil through which this canal runs, it may fairly be taken as a specimen of the maximum loss which a canal can suffer through filtrations and evaporation.

The ground through which runs the western branch of our middle section is of a quality far superior to the country through which runs the Narbonne Canal. It is, for six and one-fourth miles, of an excellent quality; the remaining eight and one-half miles run through a rugged and rocky soil, but clay is everywhere at hand to puddle the bed of the canal, if necessary. Supposing, therefore, that its losses from filtrations and evaporation equaled in one month the cube of its prism, or 519,200 cubic yards, this would certainly be their maximum, while the evaluation of 492,034 cubic yards of water, which we have given as the supply from the reservoir of Deep Creek in one month, is its minimum. For it must be remembered that we valued this supply from the lowest result, obtained at the lowest stage of Deep Creek, when it gave only five and one-eighth cubic feet in a second.

We have allowed no loss for the evaporation from the surface of the reservoir, as it will be compensated by the frequent rains which fall on the summit of the Alleghany. From observations made in July, August, September, and October, 1824, in the valley of Deep Creek, we have ascertained that there fell, from 19th to 30th July, four days of rain, 4.36 inches, 55° mean temperature; from 1st to 31st August, eight days of rain, 2.31

inches, 63° mean temperature; from 1st to 30th September, twelve days of rain, 3.15 inches, 51° mean temperature; from 1st to 31st October, nine days of rain, 3.19 inches, 44° mean temperature; from 19th July to 31st October, thirty-three days of rain, 13.01 inches. During one hundred and four days, of which thirty-three were rainy, there fell 13.01 inches of rain. The evaporation was 0.10 inch a day, and during the one hundred and four days, 10.40 inches; of course the rain more than supplied the loss of evaporation.

The temperatures marked above are the mean temperatures of the rainy days. The highest temperatures in that valley, during these months, were at midday; in July, 76°; in August, 74°; in September, 70°; in October, 72°. The lowest were at 6 in the morning; in July, 53°; in August, 44°; in September, 32°; in October, 25°. From these observations it is evident that less evaporation is to be apprehended in the valley of Deep Creek than in regions nearer to the level of the ocean; besides, by raising the dam which forms its reservoir, we might add to it a quantity of water sufficient to supply all the loss of its evaporation and filtration. We will conclude these remarks on the reservoir of Deep Creek by observing that its surface lies below the mouths of its tributaries, and that they might, therefore, at small expense, be turned into reservoirs to preserve the waters of the valley, when (the great reservoir of Deep Creek being full) they would otherwise escape over the dam. For this purpose, the dams of these small streams should have sluice-gates, to distribute their supplies whenever required.

SUMMIT-LEVEL OF THE MIDDLE SECTION.

From these observations it is evident that the eastern and western branches of the middle section possess sufficient supplies to repair their losses from filtrations and evaporation. The first is fifteen, and the second fourteen and three-fourths miles in length; and both, twenty-nine and three-fourths miles. If we subtract this length from that of the whole Deep Creek route, forty-one miles 718 yards, there will remain eleven miles 1,158 yards, or about eleven and three-fourths miles. If we subtract it from the length of the Youghiogheny route, (fifty miles 1,172 yards,) there will remain twenty miles 1,580 yards, or about twenty-one miles. These portions, on either of these routes, may be designated as their summit-levels. On the Youghiogheny route this portion might, perhaps, be dropped below the reservoirs of the Youghiogheny; but its length and expanse of water, which is our present object, would remain the same on either level. We should now examine, first, what means exist to feed these summit-levels; second, what each of these requires to supply all its wants and losses; third, what are the respective advantages of the one and the other, and which is the most advantageous with respect to that question.

The Great and Little Youghiogheny and their upper tributaries are the only streams of any importance which can feed either of these summit-levels. Their levels with respect to the base-mark, and at different points, are as follows:

	Feet.
Level of the Great Youghiogheny, at the mouth of Deep Creek below the base-mark	250. 00
Level of the Great Youghiogheny, at the head of Swallow Falls, below the base-mark	140. 81
Level of the Great Youghiogheny, one mile above the mouth of Indian Run, below the base-mark	70. 50
Level of the Great Youghiogheny, two miles above the mouth of Indian Run, below the base-mark	64. 00
Level of the Great Youghiogheny, at the mouth of the Little Youghiogheny, below the base-mark	53. 00
Level of the Great Youghiogheny, at the mouth of Snow Creek, two miles above the bridge, below the base-mark	36. 69
Level of the Great Youghiogheny, at Charles Glade's Run, below the base-mark	28. 72
Level of the Great Youghiogheny, at the mouth of Cherry tree Creek, below the base-mark	26. 18
Level of the Little Youghiogheny, where it is crossed by the State road, below the base-mark	44. 00

These levels being all below the base-mark, proved that whichever summit-level we adopt we must elevate the waters of the two Youghioghenies by throwing great dams across them. The height of these dams would be lower and a less quantity of lockage required if we dropped the summit-level of the Youghiogheny route; but the length of the tunnel from Crabby's Arm, and deep cutting at each of its extremities, would then be proportionably augmented. For the sake of comparison, we have, therefore, supposed those two routes on a level. A passage was sought to open a communication between Deep Creek and the Great Youghiogheny through the opposite valleys of

Indian Run and Cranberry Run. But as the sources of these runs rise 226 feet above the base-mark, and the Youghiogheny at the Indian Run lies 70.50 feet below it, a dam across the Youghiogheny, and tunnel through the Roman Nose Ridge, would both be indispensably required to accomplish this object.

An attempt was also made to lead Muddy Creek, which from the west falls in the Youghiogheny, to the summit-level of these routes. But to lead it to the summit-level of the Deep Creek route it would be necessary to conduct it by a long aqueduct upward of 140 feet high, and to lead it to that of the Youghiogheny, to run a feeder upward of thirty miles before it reached the mouth of Indian Run, and which would absorb by filtrations and evaporation, during its course, most of the water which it would receive. Aqueducts through the ravines which it should wind around would shorten it, but a great number of them would be required, and their construction would be very costly.

To ascertain the relative levels of Pine Swamp (where rise the springs of Muddy Creek of Youghiogheny, and Muddy Creek of Cheat River) and Deep Creek, a level was run to the summit of the ridge which divides the waters of the Youghiogheny and Cheat Rivers; this ridge, parallel to the Roman Nose Ridge, is called Snaggy Mountain. From this level it appeared that the point from which rise the highest springs of the two Muddy Creeks is 75 feet above Pine Swamp, and 226.77 feet above the base-mark. This result, which proved the impossibility of running the canal in this direction from the mouth of Deep Creek, proved also that a reservoir of three or four miles area might be formed in the Pine Swamp, and that being raised at least 150 feet above the base-mark, a feeder might be led from it, following the eastern ridge of Snaggy Mountain, and joining Snowy Creek, after winding around the heads of the tributaries of the Youghiogheny, from Snowy Creek to Muddy Creek. This feeder would be from eight to twelve miles long, and to form the reservoir a dam might be thrown through Muddy Creek, of the Youghiogheny, at the gap where it breaks through Snaggy Mountain. This reservoir would afford an important supply, if those of the Little and Great Youghiogheny should prove insufficient to feed the summit-levels. We shall now enumerate and measure the capacity of these several reservoirs, and give all the necessary details of them.

Reservoir No. 1 might be formed in the main branch of the Great Youghiogheny by throwing a dam across it, above the mouth of Cherrytree Creek. It should be 40 feet high to raise the water 6 feet above the summit-level and allow to the feeder a descent of 6 inches per mile; height of its dam, 40 feet, and length of its feeder, to the dam in Deep Creek, sixteen miles. Area of the reservoir exposed to evaporation, 2,894,333 square yards; its prism, or capacity of water above the base-mark, 5,523,370 cubic yards.

No. 2 might be formed in Cherry Creek by throwing a dam across it above its mouth. The dam should be 40 feet high, and the length of its feeder sixteen miles. For this and all the following reservoirs we shall allow the same data, 6 feet water above the base-mark and 6 inches descent per mile for their feeders. Area, 1,752,000 square yards; prism, 3,170,148 cubic yards.

No. 3 might be formed on Youghiogheny, between Cherry and Snowy Creeks, by throwing a dam through it above the mouth of Snowy Creek. Height of the dam, 50 feet; length of the feeder, fourteen miles. Area, 1,475,444 square yards; prism, 2,796,518 cubic yards.

No. 4, receiving Laurel Creek and Snowy Creek, might be formed by throwing a dam across the latter above its mouth. Height of its dam, 50 feet; length of its feeder, fourteen miles. Area, 3,444,444 square yards; prism, 6,536,666 cubic yards.

No. 5 might be formed in the Great Youghiogheny, between Snowy Creek and the Little Youghiogheny, by throwing a dam across it above the mouth of the Little Youghiogheny. Height of the dam, 67 feet; length of the feeder, ten and a half miles. Area, 2,833,332 square yards; prism, 5,555,555 cubic yards.

No. 6 might be formed in the Little Youghiogheny by throwing a dam across its mouth. Height of the dam, 67 feet; length of the feeder, eleven miles. Area, 53,375 square yards; prism, 106,750 cubic yards.

No. 7 might be formed in Dunker's Lick, by throwing a dam across it, above its mouth. Height of the dam, 75 feet; length of the feeder, nine miles. Area, 1,055,555 square yards; prism, 1,851,851 cubic yards.

No. 8 might be formed in the Great Youghiogheny, between the mouth of the Little Youghiogheny and the ledge, by throwing a dam across the ledge. The height of this dam, 94½ feet; length of the feeder, six and a half miles. Area, 2,770,666 square yards; prism, 5,303,555 cubic yards. Area of all the reservoirs, 16,279,149 square yards; prism of all the reservoirs, 30,844,413 cubic yards.

If we dispense with the last two reservoirs, whose dams are the highest and most expensive, the five remaining reservoirs above the mouth of the Little Youghiogheny will contain: Area exposed to evaporation, 12,452,928 square yards, or 4½ square miles, or 2,572.80 acres. Prism of their waters, 6 feet above the base-mark, besides

6 inches allowed per mile of the length of the feeder of each reservoir for its descent. These are all available to supply the summit-level 23,689,007 cubic yards.

These reservoirs are all independent of one another, and the higher ones may pour the surplus of their waters into the lower ones. Those numbered 3 and 5 in the Great Youghiogheny may be regarded as one, to which all the others can contribute when circumstances require it. The dam No. 3 might even be suppressed, which would reduce the number of dams to 5, but the proper location of these dams, as also their number and dimensions, will receive further investigation, which belong to the final project; their number will likely be reduced.

As to the total quantity of water which these basins might hold, if we suppose their mean depth 16 yards, and a middle horizontal section run between the surface and bottom, equal in area to one-half of the upper surface, or to 6,226,464 square yards, (half of 12,452,928 square yards,) it will amount to 99,623,424 cubic yards, or, in round terms, 100,000,000 cubic yards.

As to the time necessary to fill them, from observations taken with care, from 1817 to 1824, inclusive, by Mr. Lewis Brantz, in the vicinity of Baltimore, Md., we have the following results: In the course of eight years, from 1817 to 1824, there fell, on a mean average, yearly, 39.89 inches. In 1822 there fell the smallest quantity. The summer was very dry, vegetation deficient; the crops of grain were short. The quantity of rain which fell that year was 29.20 inches. The greatest quantity which fell was in 1817. It amounted to 48.55 inches. Applying these data to the country round the summit-level, and using only the results of the year 1822, the rain which fell in the first three and last three months of this year amounted to 16.70 inches, while that which fell in the same months of the year 1817 amounted to 18.40 inches. These 16.70 inches are equivalent to 0.465 cubic yards. Thus, during the first three and last months of each year, there will fall at least 0.46 cubic yards of rain on each square yard of the heads of the Youghiogheny, and an area of 217,391,304 square yards would be required to collect water for filling the 100,000,000 cubic yards of the reservoirs. This area amounts to 70.18 square miles; and the area of the valleys of the two Youghioghenies, above their junction, and the surface of the reservoirs amounts to much more. Besides, the heads of Cheat River could, perhaps, be brought to feed the reservoirs. These reservoirs once filled, the mass of waters which lies lower than the head of the feeders will never alter, and the upper part, which feeds the summit-level, will alone require to be renewed every year. We have seen that it contains 23,689,007 cubic yards.

The least quantity of water which the Great Youghiogheny gave in 1824, under the bridge on the road from Mansfield to Morgantown, was on the 21st of September—22.58 feet in a second. The little Youghiogheny gave, on the 23d of September, 1824, at German bridge, 4.30 feet. Total given by those two streams in a second, at their lowest stage, 26.88 feet.

This is the minimum which they can give to supply the reservoirs. In one month it would amount to 2,580,480 cubic yards, and supposing, what is most unlikely, that the two Youghioghenies and their tributaries should remain in this state, and give no more for six months, from May to October, it would supply the reservoirs with 15,482,880 cubic yards; and as during the six preceding months they would have received much more, they would be full at the opening of navigation, and receive every month at least 2,580,480 cubic yards as regular tribute.

We do not consider in this calculation the loss by filtration and evaporation, for by raising the dams of the reservoirs, a quantity of water would be added to them, which would overbalance it.

We must now compare those supplies, the minimum of what the heads of the two Youghioghenies can furnish, with the maximum of what either of the two summit-levels will require.

They will both require the same expense of water for lockage. We know that two lockfuls is the maximum expense for raising or lowering a boat, and eight minutes are required for its passage through a lock of 30 yards in length, 54 yards in breadth, and 24 yards in lift. Such a lock will contain 426.66 cubic yards, without deducting from it the draught of water of the boat, and its passage (at the maximum) will thus consume 853.32 cubic yards, or 854 cubic yards at most. Now, if the canal is navigated nine months, or two hundred and seventy days a year, at ten hours a day, and that the locks of the summit-level be kept in constant operation all that time, they might pass, allowing eight minutes for each boat, 20,250 boats, at an expense of water equal to 17,293,500 cubic yards for the nine months, or 1,921,500 cubic yards a month. This maximum of water for the expense of lockage is 658,980 cubic yards less than the minimum which the reservoirs will receive during that time.

The expense of water for lockage being 17,293,500 cubic yards, and the reservoirs containing 23,689,007 cubic yards, there will remain in reserve to supply the losses of the summit-level from filtrations and evaporation, 6,395,507 cubic yards.

The summit-level of Deep Creek, extending eleven and three-quarter miles in length, will require 413,600 cubic yards to fill it; and supposing that it loses by filtrations

and evaporation the value of its prism every month, or nine times in the year, it will expend 3,722,400 cubic yards. The profile of its feeder having a supposed area of 10 square yards, and a length of ten and one-half miles, it will consume, at the same rate, 1,663,200 cubic yards. Total consumption for nine months, 5,385,600 cubic yards. Retrenching this quantity from the surplus mass of the reservoirs, there will still remain 1,009,907 cubic yards, which, after supplying all the waste of lockage and the losses of the summit-level from filtrations and evaporation, will serve as an additional supply to repair those of the eastern and western branches of the middle section.

The Yonghioghenny summit-level, extending twenty-one miles in length, will lose, from filtrations and evaporation, on the same principle, 739,200 cubic yards a month, (the value of its prism,) and 6,652,800 cubic yards in nine months. It would thus absorb the whole surplus mass of the reservoirs, after the waste of lockage, and require a much greater expenditure of water than the Deep Creek summit-level.

Thus the important advantages of a greater supply of water, of a length shorter by nine miles, of a tunnel shorter by two and a half miles, render the Deep Creek route superior to the other; though the final surveys only can settle that point, yet at this stage of our operations we would recommend that route in preference. However, the analysis which we have just concluded is a convincing proof that a canal by either of those routes over the chain of the Alleghanies, between the mouths of Savage River and Bear Creek, is perfectly practicable. The total distance from the mouth of Savage River to that of Bear Creek will be forty-one miles at least; the rise from the mouth of Savage River to the base-mark, 1,432 feet; and the fall from the base-mark to the mouth of Bear Creek, 956.35 feet; total of lockage, 2,388.35 feet.

The preparatory surveys executed on this middle section were performed by Captain McNeill, of the United States Topographical Engineers, and Mr. Shriver, assistant civil engineer, employed by the United States. The talents and activity displayed by these gentlemen and their assistants enabled the board to collect the facts on which they rest their opinion of the practicability of this middle section, and of the best direction through which its route can be directed.

Captain McNeill was assisted in these labors by Messrs. De Russy, Cook, Trimble, Hazard, Dillahunty, Fessenden, and Williams, lieutenants of artillery, whose scientific education, imbibed in the Academy at West Point, was thus made valuable in the most efficient and useful manner to their country and to themselves. Mr. Shriver was assisted by Messrs. Jonathan Knight, John S. Williams, Freeman Lewis, and Joseph Shriver. The memoirs, surveys, and maps of these gentlemen accompany this report.

Before we conclude the article relating to this middle section, we should give an analysis of two other routes which have been proposed for leading the canal over the Alleghany; the one by ascending Will's Creek, (a stream which falls in the Potomac at Cumberland,) and descending to the Yonghioghenny by the valley of Casselman's River; the other by passing from the valley of the Potomac to that of Cheat River, and thus descending to the Monongahela.

First. Two of the head springs of Will's Creek rise very near Flaugherty Creek, which falls in Casselman's River, below Salisbury; the eastern is called Laurel Run and the other Shock's Run. The shortest distance between Laurel Run and Flaugherty Creek is one mile 756 yards. It was measured from Wilhelm's saw-mill, on Laurel Run, to Engle's saw-mill, on Flaugherty Creek. The first is 156 feet lower than the second. A deep cut of 333 yards long and 35 feet deep, in the highest part of it, on the side of Engle's saw-mill, a tunnel of 1,483 yards, and another deep cut 700 yards long and of the same depth as the former, on the side of Laurel Run, would be required to unite those two streams. The greatest height of the ridge above the bed of the tunnel would be 156 feet. This route offers great advantages if we only considered the shortness of the distance and tunnel; but as to the essential condition of a sufficient supply of water, it is absolutely out of the question. Flaugherty's Creek, at Engle's mill, gives only 0.415 cubic foot in a second, and Laurel Run, at Wilhelm's mill, 0.600 cubic foot, (at their lowest stage in 1824.) They would only give, together, 1.015 cubic feet per second to feed the whole summit-level. The details, which we have already given in analyzing the Deep Creek route and summit-level, are sufficient to show the impracticability of running a canal by the route of Flaugherty's Creek with so small a supply of water.

As to the route between Shock's Fork and Flaugherty's Creek, the season was too advanced to measure accurately its length, or the tunnel and deep cuts which it would require.

Their profile will be surveyed next season. This route would be longer than the other, and its summit-level should be fed by the waters of Castleman's River above Salisbury, led by a feeder to the western extremity of the tunnel. This feeder, following the eastern side of Castleman's Valley, would receive the waters of its tributaries between Salisbury and Flaugherty's Creek. At their lowest stage these tributaries gave, together, 5 feet in a second, and Castleman's River, above Salisbury, 15.33 cubic feet; total, 20.33 cubic feet to feed the summit-level. This quantity is not considerable when we consider that, on a length of thirty miles from the summit-level to Cumber-

land, the canal would have to draw most of its water from Castleman's River, for Will's Creek is a torrent, which, in the greatest part of its course, gives but little water in summer. The length of this summit-level, and of the route which the canal would thus trace, are less than by Deep Creek. As to their comparative heights, no survey was made in the season of 1824 to ascertain the difference. We shall now expose the reasons why the western branch of the canal was not led through the valley of the Monongahela, (before concluding this part of our report.)

We have already seen that the valley of Cheat River, through which it would be necessary to pass to the Monongahela, is divided from the Upper Youghiogheny by a ridge whose greatest depression, at the head of the two Muddy Creeks, is 226.77 feet above the level of the base-mark. A tunnel would, therefore, be necessary to pass from the valley of the Youghiogheny to that of Cheat River.

A single inspection of the map will show that the route of the canal would be very much lengthened by running its summit-level from the heads of the North Branch of the Potomac to those of Cheat River, and that it should be raised to a much higher level than on the route of Deep Creek. There is every reason to believe that the bed of Cheat River has a more rapid descent than that of the Youghiogheny; and that where it forces through the Laurel Hill, it is already nearly on a level with the Youghiogheny at Connellsville, for at this gap and a little above Furnace Run it begins to be navigable. Its bed is here about 150 yards wide. The highest floods in Cheat River do not rise above eight or ten feet at Furnace Run, and at its lowest stage in August and September it is very low at this place, and often fordable. Indeed, Cheat River to its junction with the Monongahela receives no stream of any importance but the Big Sandy, whose supply is constant, but in the summer is very trifling, even toward its mouth and in the lower part of its course. After descending along a rocky and very precipitous bed, Cheat River mingles its clear and limped waters with the muddy stream of the Monongahela, whose bed and shores are all formed of alluvial soil.

The Monongahela has absolutely the same features as the Ohio; its shores are flat, but raised perpendicularly along both sides of the river to the height of 15 or 25 feet above the line of water, formed of a rich alluvial soil. They are covered by the current, and when the river rises they crumble into it and render its waters muddy. The floods of the Monongahela are considerable. At Brownsville it rises 38 feet, while at its lowest stage its depth is only from 12 to 15 inches on its highest bars. The two banks present all along a succession of flats and bluffs. The flats of one bank are generally opposite to the bluffs of the other, and the former are found where the river expands, while the latter close on its banks where it narrows. The chief tributaries of the Monongahela are on its right shore: George's Creek, below Mr. Gallatin's residence; Big Redstone, below Brownsville; and on the left, Ten-Mile Creek. These streams flow constantly, but in summer give but a small quantity of water; an observation which is also applicable to many of the tributaries of the Youghiogheny.

If the western section of the Chesapeake and Ohio Canal cannot be led to the Monongahela, it will at least embranch with it at McKeesport, and perhaps, when a denser population will render it desirable, a line of junction may be drawn between Cheat River and the Valley of Youghiogheny. It would be fed by a reservoir above the gap of Cheat River and the constant springs which run from the western ridge of Laurel Hill.

WESTERN SECTION.

This section begins at the mouth of Bear Creek and ends at Pittsburgh, descending the valleys of the Youghiogheny and Monongahela to the Ohio.

From the mouth of Bear Creek to that of Castleman's River the Youghiogheny runs in a very winding course between a succession of flats and bluffs, the flats of one shore being generally opposed to the bluffs of the other; the banks high and rugged where they wind in, and flat where they wind out. The two banks present nearly the same difficulties. The right shore, however, seems the best. The distance between those points, following the winding of the river, is about sixteen and a half miles.

Castleman's River is about one hundred yards wide at its mouth. It is a fine river, and will give a great deal of water to the canal. At the driest season it offers from 8 inches to 1 foot in depth. Before joining the Youghiogheny it receives Laurel Hill Creek.

From the mouth of Castleman's River till you reach two or three miles above Connellsville, the Youghiogheny forces through Briery Mountain and Laurel Hill, and its bed is very deep. The left bank is very high and rugged, the right somewhat less. In this space of about twenty-eight and a half miles the canal must be frequently cut in a shelf on the sides of the valley, or run on embankments supported by a wall. The river has a fall of about 16 feet at Ohiopyle Falls; it is here about 150 yards wide.

Connellsville is considered as the head of navigation in the Youghiogheny. In the driest season it has here from 8 inches to 1 foot in depth.

From Connellsville to Robstown the river winds during twenty-four or twenty-five

miles. On all this extent the right bank is far preferable to the other. Except in three or four places, where you meet with bluffs, it consists of flats or gentle slopes, where the canal can be run without difficulty. As to these bluffs, they consist of schistose rock, easy to work. The only stream of any importance which joins the Youghiogheny between Connellsville and Robstown is Jacob's Creek, and it gives but little water in dry seasons. That route is also intercepted by two or three deep ravines, which the canal must cross on aqueducts.

The distance between Robstown and McKeesport is about sixteen miles. Along this route the right shore remains preferable to the other; it consists of a succession of flats and spurs, which, being of a schistose nature and moderate height, will offer no considerable obstructions to the canal.

From McKeesport to Pittsburgh the right shore of the Monongahela offers a most favorable ground, except along the two spaces of about a mile each, where rugged bluffs close on the river. The first is below Judge Wallis' and the field of Braddock's defeat; the second before reaching Pittsburgh. The whole distance, in following the right bank of the river, is between McKeesport and Pittsburgh, from fifteen to sixteen miles.

The highest floods of the Youghiogheny occur between Castleman's River and Connellsville; they rise to 18 feet. At Connellsville they rise from 12 to 15 feet. Salt-wells may be dug in its valley; coal and iron are abundant; and excellent materials for building, timber and stone, are found all along it.

The preparatory surveys of this western section were not commenced during the last season, 1824. They can alone fix the general route of the canal; they will be directed on the following bases: From Bear Creek the canal must follow the right shore of the valley, descending along the Youghiogheny; and, though it is most favorable, (presenting a rugged bank only for four or five hundred yards,) when it reaches Selbysport bridge two lines of direction may be tried, one along the right and the other along the left bank, to the old salt-works. The depth and breadth of the valleys and ravines, which it will be necessary to cross on aqueducts, will be measured, and the location of these aqueducts and of the dams to form reservoirs will be fixed. If between Selbysport and the old salt-works the left shore presents any advantages over the other deserving the expense and trouble of crossing twice the Youghiogheny, the location and dimensions of two aqueducts, one at Selbysport and above the old salt-works, will be determined, and a feeder led from Castleman's River to the latter.

From the old salt-works to the Ohiopyle Falls the canal must follow the right shore, which is most favorable, and then, crossing Indian Creek on an aqueduct, continue along the same bank to the paper-mill, four or five miles south of Connellsville. It will be proper to ascertain whether its line should not leave the valley of the Youghiogheny above the Ohiopyle Falls, and, running east, gain the southern branch of Indian Creek, to rejoin the Youghiogheny by descending Indian Creek Valley.

From the paper-mill the canal should be run at a sufficient elevation above the river to leave the shore, and gain, if possible, the high level which lies east of Connellsville, in order to turn round the rugged bluff below that place. From thence, following the right shore, it will reach Robstown, after crossing on aqueducts Maunet's Creek and Jacob's Creek. The localities and dimensions of these aqueducts must be determined, as well as the resources which these streams may afford to supply the canal by turning them into reservoirs.

From Robstown to McKeesport, keeping along the right shore, it must cross Sewickly Creek over an aqueduct, whose dimensions and location must be determined. As this creek has two considerable branches, they must be examined to determine whether reservoirs cannot be made in them. From McKeesport to Pittsburgh the canal will follow the right shore of the valley of the Monongahela, crossing in succession Crooked Run, Turtle Creek, and Nine-Mile Run on aqueducts.

To ascertain whether from the paper-mill the right shores of the Youghiogheny and Monongahela are certainly the best, a level should be run along their valleys on the left shore, and the locations and dimensions of the dams or aqueducts which it would be necessary to run through the Youghiogheny at McKeesport and through the Monongahela near its confluence with the Youghiogheny, in case this route was adopted, should be fixed and calculated.

It will also be essential to try whether the canal might not turn to the west of that narrow and rugged portion of the valley of the Youghiogheny where it forces its way through Briery Mountain and Laurel Hill. For this purpose a level should be run from Selbysport and some point of a proper elevation, and cross the Briery Mountain at the depression which it offers between the heads of Buffalo Marsh Run and the eastern branch of Sandy Creek. This level should then wind round the ravines of the head of the western branch of Sandy Creek till it met the Laurel Hill at the spot where it might be crossed by the shortest tunnel. When it reaches its western slope it should run northwardly along its foot, to descend by one of its ravines to the Youghiogheny opposite the paper-mills.

On the whole, the western section of the canal, from the mouth of Bear Creek to that of the Monongahela at Pittsburgh, offers no obstacles which may not be surmounted

at a reasonable expense; and the waters of the Youghiogheny, Bear Creek, and Castleman's River are amply sufficient to feed it. Large reservoirs may be formed in Bear Creek and Castleman's River by throwing dams across them, and on the route from Castleman's to the paper-mills, and at the mouth of the Youghiogheny in the Monongahela. The practicability of this section is out of the question.

Its length will be about one hundred miles, and its descent from Bear Creek to Pittsburgh 584½ feet, as Pittsburgh is 756 feet above the level of the ocean. The investigation of the topography and water-courses of the country through which the Chesapeake and Ohio Canal should run, and the results of our preparatory surveys, obtained up to the present moment, demonstrate that this noble enterprise is practicable; and, although we have not yet sufficient data to calculate the expense of the work, there is every probability that it will not bear any comparison with the political, commercial, and military advantages which it will procure to the Union.

The total result of the length, rise, and fall of the canal is as follows:

<i>Total length :</i>		Miles.
From the tide-water in the Potomac to Cumberland, (from Messrs. Moore and Briggs' survey).....		182
From Cumberland to the mouth of Savage River, (from report of Major Abert, United States Topographical Engineers).....		27½
From the mouth of Savage River to that of Bear Creek, by the Deep Creek route, from the surveys of Captain McNeill, United States Topographical Engineers, and Mr. Shriver, United States assistant civil engineer).....		41
From the mouth of Bear Creek to Pittsburgh, (from Mr. Shriver's computation)		100
		350½
<i>Total rise :</i>		Feet.
From tide-water in the Potomac to Cumberland, (from the profile of Cumberland road)		537
From Cumberland to the mouth of Savage River, (from Major Abert's survey)		327½
From the mouth of Savage River to the base-mark on the Deep Creek summit-level, (from Captain McNeill's survey)		1,432
		2,296½
<i>Total descent :</i>		Feet.
From the base-mark to the mouth of Bear Creek.....		956
From thence to the Ohio, at Pittsburgh.....		584½
		1,540½
Total lockage for rise and descent.....		3,837
* * * * *		

S. BERNARD,
Brigadier-General.
JOS. G. TOTTEN,

Major Engineers, and Brevet Lieutenant-Colonel.

REPORT OF THE BOARD OF INTERNAL IMPROVEMENT ON THE CHESAPEAKE AND OHIO CANAL, COMPRISING THE PLAN AND ESTIMATE OF THE SAME, OCTOBER 23, 1826.

The operations which have been executed in the field in 1824 in relation to the contemplated Chesapeake and Ohio Canal had chiefly for object to ascertain the practicability of the undertaking. Those performed in 1825 were to determine the route to be recommended, as also to obtain the data necessary to frame a general plan of the work and a preparatory estimate of the expense.

Another series of operations remains yet to be executed: 1. To locate accurately the canal on the ground, and to fix the final site of the locks, aqueducts, culverts, dams, bridges, &c. 2. To frame for each portion of canal the plans and profiles necessary for its execution. 3. To make on the spot the calculations of excavation and embankment. 4. To draw up the estimate of each individual work according to local circumstances. 5. To prepare the proper specifications to put the work under contract. This series of operations belongs more properly to the construction than to the general plan of the canal, and may be deferred until the execution shall have been decided. These operations will then keep pace with the execution of the work, and their results for each portion will improve by the experience gradually acquired during the construction of the canal.

These considerations, the scarcity of means at our disposal at this time, and the expediency of affording a result as to this great important national work, have induced us to limit the surveys to those strictly necessary to enable us to frame a general plan and a preparatory estimate.

In the report submitted by the board on the 2d of February, 1825, (marked A among the documents which accompanied the President's message of the 14th of February, 1825,) all the experimental lines surveyed in 1824 have been described, and mention has been made of several others which were yet to be surveyed. We have also presented, in the same report A, the considerations relative to the hydrography of the country in the general direction of the canal. We will, therefore, confine ourselves to the description of the experimental lines, which, on account of the advanced season in 1824, had been postponed to 1825; we will compare these lines to the others, and point out the route which seems to us entitled to preference.

EXPERIMENTAL LINES.

Summit-level by Deep Creek.—In the report A, it had been anticipated that the section of canal from the tunnel at Dewickman's Arm to the mouth of Bear Creek would follow the valley of Deep Creek as far as the Rapids, then turn Panther's Point, and descend to the mouth of Bear Creek, along the left side of the Youghiogheny. However, it became necessary to compare this route with another more direct, which, following the former as far as Deep Creek bridge, would continue to Rock Creek Run, a western tributary of Bear Creek. The survey has shown that, the bottom of canal being assumed three feet above the bottom of Deep Creek at the bridge, a tunnel would be necessary to cross the ridge which separates Buffalo Marsh Run from Rock Lick Run. The distance and descent are as follows:

Sections.	Miles.	Yards.	Feet.
From the eastern end of the tunnel at Dewickman's Arm to the base-mark at Deep Creek	6	1,048	.....
Descent in this distance .....			.....
From the base-mark to the debouch into Rock Lick Run	5	38½	.....
Descent in this distance .....			.....
From this debouch to the mouth of Bear Creek	7	535½	.....
Descent in this distance			912
Total	18	1,622	912

In this total distance, two tunnels would be necessary: one at Dewickman's Arm, whose length would be one mile 568 yards, and whose bottom would be below the top of the ridge 233 feet; one at Buffalo Marsh Run, whose length would be two miles 254 yards, and whose bottom would be below the top of the ridge 343 feet; total length of tunnels three miles 822 yards.

In order to remove all doubts as to the expediency of this portion of canal-route, and to lessen, as much as practicable, the length of the tunnels and the excavation at their deep cuts, a second line, 13 feet 9 inches higher than the preceding one, has been tried; the results of which are as follows:

Sections.	Miles.	Yards.	Feet.
From the eastern end of the tunnel at Dewickman's Arm to the base-mark at Deep Creek bridge	7	216	.....
Descent in this distance .....			.....
From the base-mark to the debouch into Rock Lick Run	5	38½	.....
Descent in this distance .....			.....
From this debouch to the mouth of Bear Creek	7	535½	.....
Descent in this distance			922½
Total	19	790	922½

As to the length of the tunnels and the height of the ridges above the bottom of tunnels, they are respectively:

Sections.	Miles.	Yards.	Feet.
Dewickman's Arm, length	1	978	.....
Height of the ridge			219½
Buffalo Marsh Run, length	1	2,215	.....
Height of the ridge			320½
Total	2	1,493	.....

This arrangement would lessen the length of tunnels by 1,089 yards, and also the excavation through the valley of Deep Creek by at least 1,000,000 cubic yards. But the level of this route being 13½ feet higher than that of the former route, the volume of available water in the reservoir of Deep Creek would be much diminished, and it would also become necessary to raise, by 13½ feet, the dams recommended (in the report A) across the Youghiogheny, in order to feed the canal; a circumstance which would increase the expense and difficulty attending the erection of these dams. It must be observed that Deep Creek alone is altogether unable to feed a summit-level, while it scarcely yields, during the dry season, 5 cubic feet of water per second. Its tributaries are liable to become entirely dry, as happened in 1825.

However, we will compare this direct route, running from Dewickman's Arm to the mouth of Bear Creek, with that through Deep Creek and the right side of the Youghiogheny, and whose distance and descent are as follows:

Sections.	Miles.	Yards.	Feet.
From the eastern end of the tunnel at Dewickman's Arm to the base-mark at Deep Creek bridge	6	1,048	.....
Descent in this distance	6	204½	.....
From the base-mark to the western end of the summit-level	15	100	.....
Descent in this distance			913
From the western end of the summit-level to the mouth of Bear Creek			
Descent in this distance			
Total	27	1,352½	912

On this portion of route there would be one tunnel only, (at Dewickman's Arm,) whose length, as already stated, would be one mile 568 yards. The distance and descent in following the direct route would be, as above, nineteen miles 790 yards 925½ feet.

The length of the two tunnels taken together would be, as above, two miles 1,493 yards.

The direct route would, therefore, be eight miles 562½ yards shorter than the other, but it would require a greater length of tunnel by one mile 568 yards, and cause an increase of lockage of 27½ feet, which, as to time and expense, gives a decided advantage to the other route. Again, the descent from the debouch into Rock Lick Run to the mouth of Bear Creek is 925½ feet, on a distance of seven miles 535½ yards, which, on the supposition of a uniform declivity, could afford but 115 yards to the location of one lock, 8 feet lift, with its adjoining pond; but this declivity is far from being uniform, and in some places it will be so rapid as to oblige to locate the locks quite close to each other, a circumstance which would involve the expense of a double set of locks. All these considerations, added to the difficulty of feeding the upper level, induce us to reject this direct route, and to give the preference to that through the valleys of Deep Creek and of the Youghiogheny, as assumed in the report A, (February, 1825.)

Summit-level by Flaugherly Creek.—But a much more important route was yet to be examined, which, having its summit-level at the source of Will's Creek, would commence at Cumberland, ascend this creek, cross the ridge which separates Will's Creek from Castleman's River, and descend the valley of this stream to debouch into the Youghiogheny at its junction with Castleman's River and Laurel Hill Run. Mention has been made of this route in report A, (pages 40 and 41.) Some experimental lines were surveyed on the summit-ground in 1824, and some measurements of water were taken; but the season being then too far advanced to prosecute further the surveys and levelings relative to this route, the board were compelled to defer their execution until 1825; and as early as the 12th of March, 1825, they framed detailed instructions respecting the surveys and investigations necessary to ascertain the practicability of a route of canal in this direction. This route deserved so much the more a careful examination that it promised, by means of a tunnel, a shorter distance, but it became necessary to ascertain, in the first instance, the minimum length of the tunnel which should receive, at its western end, water enough from Castleman's River to supply the summit-level and a portion of the canal down Will's Creek. Upon this point rested the practicability of this route. Indeed, the survey made in 1824 had tried a tunnel of 1,483 yards in length, with a greatest height of ridge of 156 feet; but the essential condition of a sufficient supply of water had not been obtained at such an elevation. It therefore remained to find out, by surveys, a tunnel combining the shortest length with a competent supply of water. These surveys were intrusted to Capt. Wm. G. McNeill, of the Topographical Engineers, who carried them in the most able manner, into execution.

The result has been that a tunnel from the mouth of Bowman's Run, in Will's Creek, to the mouth of Flaugherly Creek, in Castleman's River, was the shortest which could

be admitted to procure at the same time the other requisite as to the sufficiency of water. The length of this tunnel is four miles 80 yards, with a deep cut at each end; the eastern being 140 yards long, the western 1,060 yards; the greatest depth of each 35 feet, but the height of the top of the ridge above the bottom of the tunnel is not less than 856 feet.

Let us now examine the resources afforded to feed this summit-level. Castleman's River is the only stream upon which we can rely to fulfill this object. It yielded, on the 21st of June, 1825, at Pleucher's farm, twelve miles above the mouth of Flaugherty Creek, 18 cubic feet of water per second; on the 7th of the same month, it yielded at the same place 44 cubic feet per second; on the 10th of July, same year, it yielded 38 cubic feet per second, above the mouth of Flaugherty Creek. It must be observed, that in consequence of a freshet, the stream, on the 24th of June, 1825, yielded at Forney's Mill, five miles above Flaugherty Creek, 803 cubic feet per second; three days afterwards it still delivered 103 cubic feet. From all these results we adopt the smallest; and we assume 18 cubic feet as the minimum of water supplied by Castleman's above the mouth of Flaugherty Creek. Besides this supply of running water, two reservoirs can be made in the bed of the stream: one at Pleucher's farm, containing 4,679,029 cubic yards; the second, below Forney's Mill, containing 17,091,490 yards; together, about 22,000,000 yards. The dam of the first would be 40 feet high, 230 yards long at the top; the foot 114 feet above the summit-level; the dam to form the other would be 50 feet high, (to obtain a height of 40 feet of available water,) and from 140 to 160 yards long at the top. The feeder from the upper reservoir to the lower one would be about seven miles; but the feeder from the lower and larger reservoir to the summit-level would be three and one-third miles only. The area of the reservoir at Pleucher's farm will be 1,040,600 square yards; that of the great reservoir, 2,541,000 square yards; total, together, 3,581,600 square yards.

We shall, in the sequel of this report, take into more minute consideration these supplies of water; for the moment we leave the subject to present a comparison between this route of canal and that by Deep Creek, as suggested in the report A, by and in consequence of the limited facts which then it had been in our power to ascertain. The first will be designated Castleman's route, the other Deep Creek route.

The length, ascent, and descent of Castleman's route are as follows:

Sections.	Miles.	Yards.	Feet.
From Cumberland bench-mark to the eastern end of the summit-level.....	29	340	.....
Ascent in this distance.....			1,235
Summit-level: eastern basin, 880 yards; eastern deep-cut, 140 yards; tunnel, four miles 80 yards; western deep-cut, 1,060 yards; western basin, 880 yards.	5	1,280	.....
From the western end of the summit-level to the Youghiogheny, 440 yards below the mouth of Castleman's River.....	35	1,350	.....
Descent in this distance.....			636
Total distance and lockage.....	70	1,010	1,961

The length, ascent, and descent of the Deep Creek route are as follows:

Sections.	Miles.	Yards.	Feet.
From Cumberland bench-mark to the mouth of Savage River.....	30	350	.....
Ascent in this distance.....			327½
From the mouth of Savage to the mouth of Crabtree Creek.....	5		.....
Ascent in this distance.....			383
From the mouth of Crabtree Creek to the eastern end of the summit-level.....	8	1,430	.....
Ascent in this distance.....			1,651
Total ascent, 1,761½ feet.			
Summit-level: eastern deep-cut, 352 yards; tunnel, one mile 568 yards; western deep-cut, five miles 480 yards; western end, six miles 204½ yards.....	44	90	1,761½
From the western end of the summit-level to the mouth of Bear Creek.....	12	1,604½	.....
Descent in this distance.....	15	100	913
From the mouth of Bear Creek to a point in the Youghiogheny 440 yards below the mouth of Castleman's.....	16	1,075½	.....
Descent in this distance.....			164
Total descent, 1,076 feet.			
Total distance and lockage.....	88	1,040	2,357½

Both summits of these routes, being compared as to altitude to the Cumberland bench-mark, will show a difference of level of 436½ feet in favor of the Castleman route. This difference would be 440 feet, if the level of comparison were assumed at

the point of junction of these routes into the Youghiogheny; but as at this point no well-fixed bench-mark had been agreed to between the two surveying parties, we rely, in preference, on the former result. This important result shows that through Castleman's the lockage will be 73 feet less than through the other route.

As to distance, the foregoing statements exhibit a length of eighteen miles 30 yards in favor of the Castleman route; which, combined with a less amount of lockage, gives to this route, as to time, a decided advantage over the Deep Creek route.

Let us examine now which of these routes will afford the greatest facility to the location of the locks.

By assuming 8 feet as a common lift, we find that, from Cumberland to the mouth of Savage, the average distance between the heads of the two locks will be 1,296 yards; from the mouth of Savage to Crabtree Creek, 183 yards; from the mouth of Crabtree Creek to the eastern end of the summit-level, 117 yards; and this on the supposition of a uniform declivity, which is far from being the case, and more especially in the valley of Crabtree Creek, where, toward the head, the locks, on account of the steepness of the ascent, could not even find room, unless their lift should be considerably increased. To this difficulty we must add the narrowness of the valley, which would oblige to resort to very extensive means to erect, where necessary, double sets of locks, as also to shelter the work from destruction, either by high freshets or by heavy showers.

As to the western section of this route, serious difficulty would be encountered to turn Panther's Point, the sudden fall being great and the side of the valley very precipitous. It would become necessary to descend at once about 400 feet in a distance which could hardly afford room for the location of locks succeeding closely to each other without intermediate ponds. This circumstance would either necessitate a double set of locks, or oblige to stretch, at considerable expense, the line of canal around this steep spur which separates Deep Cut from Hoy's Run.

These difficulties as to the location of locks are not to be met with on the Castleman route. In the valley of Will's Creek 200 yards will be the shortest distance between the heads of two successive locks, and in that of Castleman's 300 yards. We must also remark that, though the valley of Will's Creek becomes gradually narrower above the mouth of Little Will's Creek, yet it affords room enough for the works, and these will be more easily protected against freshets and showers than they could be in the valleys of Crabtree Creek and Savage River.

The foregoing considerations show that, in relation to a less difficult location of canal, the Castleman route has (abstraction being made, for the present, of the tunnel) a decided advantage over the Deep Creek route. But another important object is also to be examined: we mean the supply of water at the respective summit-levels.

Respecting this point, it has been seen that the resources yielded by Castleman's, above the mouth of Flaherty Creek, consisted of 18 cubic feet per second of running water, and of two reservoirs of available stored water, amounting to about 22,000,000 cubic yards. As to the Deep Creek summit-level, it has been shown in report A (February, 1825,) that Deep Creek delivered, as a minimum, 5.12 cubic feet per second, (page 32;) the Little and Great Youghiogheny together, 26.88 cubic feet per second, (page 38;) total of running water, 32 cubic feet per second.

The reservoirs in Deep Creek amount to 2,214,156 cubic yards of available water, (page 32,) and those in the Youghiogheny to 23,693,007 cubic yards together, (page 37;) total, 25,907,163 cubic yards; we assume 26,000,000. These supplies of water will compare as follows:

	Cubic feet per second.		Cubic yards.
Deep Creek summit, running water...	32	Reservoirs.....	26,000,000
Castleman's summit, running water...	18	Reservoirs.....	22,000,000
Difference in favor of Deep Creek.....	14		4,000,000

But the following remarks will attenuate this advantage and induce to place these resources upon a nearer footing: 1. Deep Creek and both Youghioghenies were gauged in 1824, whereas Castleman's River was measured in 1825, whose summer and autumn were drier than those of the preceding year. 2. The feeder destined to bring the water of the Youghiogheny reservoirs on to the summit-level of Deep Creek will be about twelve miles long, while the feeder from the great reservoir below Forney's Mill will be but three and one-third miles in length. Therefore the loss of water by evaporation and leakage will be for the latter the fourth of that for the former. This fact deserves so much more due attention that experience has proved positively that such losses were by far greater in feeders than in portions of canal of the same length. 3. The 18 cubic feet per second allowed to Castleman's River were gauged at Pleucher's farm, 114 feet above the summit-level, and no account has been kept of the water delivered by Meadow Run, Tub Run, Pine Run, tributaries of Castleman's, whose mouths are below Pleucher's farm and higher than the summit-level; however, they have yielded together, as a minimum

on the last days of June and first days of July, 1825, 13.84 cubic feet per second. 4. The reservoirs in the Youghiogheny present to evaporation an area of (report A, page 37) 12,452,928 square yards, while those in Castleman's present but 3,581,600 square yards; difference in favor of the latter, 8,871,328 square yards, a difference which will cause a saving of about 6,000,000 cubic yards of water, the yearly fall of rain being supposed to be but 36 inches, and the common ratio of 5 to 3 being admitted between the yearly evaporation and fall of rain upon the surface of a given reservoir.

The foregoing facts and computations lead us to the conclusion that, with respect to water-supply, both routes may be considered as on an equal footing. It remains now to compare the expense attending the construction of either route.

The lockage on the Deep Creek route is 873 feet more than on the Castleman route; to which are to be added, for double set of locks in Crabtree, at least 350 feet, and at Panther's Point, at least 200 feet; total, 1,423 feet, or 178 locks, 8 feet lift, which would cost \$2,136,000, at the rate of \$12,000 each.

The deep cut, from the western end of the tunnel to the base-mark at Deep Creek bridge, is five miles 480 yards long, and has, at its eastern end, a depth of 40 feet, which diminishes gradually on approaching the base-mark. The amount of its excavation will be 1,407,961 cubic yards, from which, on subtracting 87,556 cubic yards, amount of excavation for the western deep-cut of the tunnel at Flagherty, it remains 1,320,405 cubic yards to the disadvantage of the Deep Creek route. On the reasonable supposition that the ground will require, for excavating, two men, one with shovel, the other with pick, and the transportation being assumed at the distance of ninety yards for an ascent of one-twelfth, this excavation will cost \$448,937.70 at the rate of 34 cents the cubic yard.

The Dewickman tunnel is one mile 568 yards long, and has 232 feet of height of ridge above its bottom.

The Flagherty tunnel is four miles 80 yards long, and has 856 feet of height of ridge above its bottom.

Difference in favor of Deep Creek, two miles 1,272 yards in length, and 623 feet in height of ridge above its bottom.

The comparative cost of these tunnels will be as follows; the substance supposed to be sandstone:

Parts.	Flagherty's.	Dewickman's.	Difference.
Shafts.....	\$233, 032 95	\$17, 108 99	\$215, 923 96
Heading.....	383, 534 83	119, 738 12	263, 796 71
Side-heading.....	7, 704 27	2, 704 27	5, 000 00
Tunnel.....	2, 495, 242 80	608, 106 50	1, 687, 136 30
Draining.....	159, 469 30	7, 010 90	152, 458 40
Total cost.....	3, 278, 984 15	954, 668 78	2, 324, 315 37

Respecting the dams to be erected across the two Youghioghenies to form the reservoirs destined to supply the Deep Creek summit, they should have at least a height of 50 feet, and may be reduced to four in number. They would also measure together a length of 1,200 yards at the least. As to those across Castleman's, they may be reduced to one only below Forney's mill; its height will be 50 feet, and its length at the top 160 yards. The expense for this object will, therefore, be seven and a half times as great for the Deep Creek as for the Castleman route.

The dam below Forney's mill will cost.....	\$27, 601 60
Therefore the dams across the Youghioghenies will cost together.....	207, 012 00

Difference in favor of the Castleman route..... 179, 410 40

Finally, the route by Deep Creek will be eighteen miles 30 yards longer than by Flagherty Creek. These eighteen miles, on the most favorable supposition of level cutting and light ground, will cost, at the rate of 13.6 cents per cubic yard, digging and transportation included, \$96,940.80.

Recapitulating, now, the extra expenses for each route, we find them as follows:

<i>Deep Creek route.</i>	
For lockage.....	\$2, 136, 000 00
For the western deep-cut.....	448, 937 70
For the dams.....	179, 410 40
For the eighteen miles.....	96, 940 80
Total.....	2, 861, 288 90

Castleman's route.

For two miles 1,272 yards of tunnel	2, 324, 315 37
Difference in favor of this route.....	536, 973 53

The Castleman route will, therefore, be less expensive than the Deep Creek route its supply of water nearly the same; its location more easy; its summit-level less liable to be encumbered at the ends; and on account of less lockage and shorter length it will produce a saving of time of twenty-two hours. All these results combined lead us to give to the Castleman route a decided preference.

Before closing this part of our report we must exhibit the results of an attempt made to avoid the rugged portion of the Youghiogheny, where the stream forces its way through Briery Mount and Laurel Hill. To this effect a route was tried, which, commencing either at the fork of Bear Creek or above the Swallow Falls, in the Youghiogheny, runs through Asher's Glade, a depression of Briery Mount, thence crosses, by a tunnel, Laurel Hill, to follow afterward its western side, and debouch into the Youghiogheny at the mouth of Dunbar Creek, one mile above Connellsville.

Mention has been made of this route in the report A, (February, 1825,) page 44. Though the single inspection of the ground had sufficiently shown that very little reliance was to be placed upon it, yet it was essential to try its degree of practicability; its surveys and levelings were, therefore, made at as long sights as the ground would admit.

The fork of Bear Creek, that is, the point where the western and eastern branches unite, has been found to be 780.93 feet below the base-mark at Deep Creek bridge, and 640.09 feet below Briery Mount at Asher's Glade; therefore, Asher's Glade is but 131.84 feet below the base-mark at Deep Creek. This fact alone shows the absolute impracticability of obtaining a line of canal in this direction. It shows, also, that whatever may be the line devised to reach Asher's Glade, it cannot be kept lower than 131.84 feet below the summit-level of Deep Creek, and must rely on the Youghiogheny alone for its supply of water; and this for its whole length, from Deep Creek to the mouth of Dunbar Creek; the resources afforded by the intervening streams being, in summer, of no consequence.

By trying a line through the left side of the Youghiogheny, we should first cross this stream by an aqueduct of more than 150 feet high, then follow the western side of the valley, to strike, in succession, the head-branches of Buffalo Creek, Big Sandy Creek, and Little Sandy Creek. The line would then cross Laurel Hill by a tunnel of one and a half miles in length and 547 feet under the ridge, and thence descend to the mouth of Dunbar Creek, after having traversed deep and numerous ravines which furrow the western side of Laurel Hill. It must be remarked that, from the Little Sandy to the mouth of Dunbar Creek, in a distance of about twelve miles, this route of canal would oppose difficulties which would be far greater than those to be met with in the valley of the Youghiogheny, where the stream breaks through Briery Mount and Laurel Hill. The distance from Deep Creek to Connellsville by this route would be seventy-one miles, and six miles longer than through the valley of the Youghiogheny; and if we add to the foregoing statements the deficiency of water, we must conclude that a canal following this direction is utterly inadmissible.

In conformity to an order of the Engineer Department, a leveling has been made, in March, 1826, in relation to a feeder destined to transfer the water-supply of Deep Creek summit to the Casselman summit. Capt. William G. McNeill, of the Topographical Engineers, to whom this duty was assigned, received from the board the necessary instructions. His report affords the following results:

Length of the feeder.

	Miles.	Yards.
From the base-mark at Deep Creek bridge to the point where the feeder meets Castleman's River.....	15	585
From this point to the bridge across Castleman's River on the National Road, (nearly).....	8	880
Thence to the reservoir at Pleacher's farm.....	1	880
Add the length of feeder from the dams in the Youghiogheny to the reservoir at Deep Creek.....	12	0
Total length.....	37	585

On this distance there are four deep cuts and two tunnels, viz :

	Miles.	Yards.
A deep cut terminating in Buffalo Marsh Run	2	757
Thence a tunnel to the valley of Bear Creek	5	930
A deep cut from the end of this tunnel	0	786
A deep cut at the western side of Negro Mountain	0	278
A tunnel through this mountain	1	1,640
A deep cut from the end of this tunnel	0	330
Together	10	1,132

Out of which, for deep cuts, having 35 feet of greater depth, three miles 313 yards for tunnels, seven miles 819 yards.

It is fortunate that so long and so expensive a feeder can be dispensed with.

The foregoing facts and investigations, connected with those exposed in the report A. (February, 1825,) lead us to recommend the following route for the Chesapeake and Ohio Canal :

From Georgetown, D. C., to Cumberland it will ascend the valley of the Potomac ; thence the valley of Will's Creek to the mouth of Bowman's Run. It will then cross the summit-ridge by a tunnel, and descend, in succession, the valleys of Casselman's River and the Youghiogheny, to terminate at Pittsburgh, Pa., at the mouth of the Monongahela.

We have now to present the description of the general plan of the work ; but as we think it more expedient to progress simultaneously with the description and estimate, we will previously give an analysis of the main prices upon which the estimate is calculated, and point out the dimensions upon which the plan is predicated.

We observe, also, that the whole line of canal will be subdivided into three distinct sections, each of them forming of itself a separate system, viz :

Eastern section, from Georgetown to Cumberland.

Middle section, from Cumberland to the mouth of Casselman's River.

Western section, from the mouth of Casselman's to Pittsburgh.

* * * * *

PLAN AND ESTIMATE OF THE CANAL.

The transverse section of the canal is exhibited on the sheet No. 3. The breadth at the bottom is 33 feet ; at the surface, 48 feet ; the depth of water, 5 feet ; the tow-path, 9 feet wide ; the guard-banks, 5 feet at the top ; the surf-berms, kept on the level of water, 2 feet wide each ; the tow-path and top of the guard-bank, 2 feet above the surface of the canal.

This transverse section is to be modified where local circumstances require it, and, more especially, in the cases of deep cutting, steep side-cutting, embanking, and also where the canal is supported by walls. In the framing of the plan a due attention has been paid to these modifications, with a view to conciliate the convenience of the work with the strictest economy. The depth of 5 feet has been preserved throughout the line, but the breadth has been often much lessened. As to the surf-berms, they are intended to protect the slopes from being washed off, as also to lessen the resistance opposed to the boat by affording to the eddy-water a free passage.

We must submit, however, the reasons which led us to propose the above dimensions.

The experiments made in 1775 by the French Academicians (D'Alembert, Condorcet, and Bossat) have shown—

1. That the resistance of water to the perpendicular motion of a given plane may be regarded as proportional to the square of the velocity.
2. That the velocity being the same, the resistance of water may be considered as proportional to the area of the plane.
3. That these results obtained only in the case of an indefinite expanse of water.
4. That in narrow canals the resistance increases in a more rapid ratio than the square of the velocity.

To attenuate as much as practicable this inconvenience, researches have been made to ascertain what should be the ratio between the transverse section of the canal and the transverse section of the boat, in order that the boat might move through such a canal as through an indefinite expanse of water.

Experiments made on the subject by the celebrated Chevalier Dubuat have shown that to attain this result the cross-section of the canal ought to be, with moderate velocities, 6.46 times the cross-section of the boat, and the water-line 4½ times the breadth of the boat.

Adopting, to preserve uniformity, $13\frac{1}{2}$ feet for the breadth of the boats used on the Chesapeake and Ohio Canal, (which is the breadth of the Erie Canal and of the Ohio Canal boats,) if we suppose the draught to be 3 feet, the prow to be rectangular, and the sides and bottom of the boat to conform to it, the cross-section of the boat will be 40.5 square feet. Taking, now, this area 6.46 times, we find $261\frac{1}{2}$ square feet for the cross-section of the canal, through which the boat would not meet with a greater resistance than through an indefinite expanse of water. The water-line should be 60 $\frac{1}{2}$ feet; that is, four times and a half the breadth of the boat.

Were not expense to be taken into consideration, these dimensions might be recommended, but fitness of the work and strict economy must be reconciled as much as practicable, and it is in such a view that smaller dimensions are to be fixed upon.

It is to be remarked that the distance from Georgetown to Pittsburgh in following the line of the canal is three hundred and forty-one and three-quarter miles, which, at the rate of two and a half miles per hour, will be traveled in about 136 hours. The ascent and descent amounting together to 3,158 feet, will require, at the rate of one minute per foot, about 52 hours; distance in time from Georgetown to Pittsburg, 188 hours. Though a number of canals, selected among those executed to this day, might afford, together, the distance and lockage found for the Chesapeake and Ohio Canal, yet there is not, within our knowledge, any line of the same extent requiring even 1,800 feet of ascent and descent taken together. The Erie Canal requires 638 feet for three hundred and sixty-two miles; the line from Liverpool to London, 1,451 $\frac{1}{2}$ feet for two hundred and sixty-four miles; the canal from the Rhone to the Rhine, connecting Lyons with Strasbourg, has about 1,458 feet of lockage for a length of two hundred miles. The proposed canal has, therefore, as to time, a decided inferiority when compared to a canal of the same length, but having a less amount of lockage; and it becomes, in the present case, indispensable to remedy this inconvenience. The means we propose consist in the increase of the dimensions of the cross-section of the canal, with a view to compensate by a greater weight (transported without additional power) for the virtual increase of distance caused by so great an amount of lockage.

We have shown that this section ought to be 261 square feet, with a water-line of 60 feet, to procure a boat 13 feet 6 inches in breadth the advantage of moving on the canal as on an indefinite extent of water. After many trials and minute calculations, we have concluded to adopt for the contemplated canal the four-fifths of the foregoing results, viz, for the cross-section 208 square feet, and for the water-line 48 feet; and from these data we have framed, with a depth of 5 feet, the general transverse profile of the canal, as exhibited on the sheet No. 3.

Let us now compare this profile to one having 40 feet at the surface, 28 feet at bottom, and 4 feet in depth; the boat used being the same for both, and having $13\frac{1}{2}$ feet in breadth, and 3 feet in draught. We find by calculation that, the velocity remaining the same, the resistance to the boat moving in the 48-foot canal is to the resistance to the same boat moving in the 40-foot canal as 1.21 to 1.58, or as 100 to 130. Therefore, at the same rate of velocity, 100 horses will, on the 48-foot canal, perform the same work as 130 horses on the 40-foot canal; and with the same towing-power the weight transported on the 48-foot canal will be to the weight transported on the 40-foot canal as 130 to 100.

But the depth of the 48-foot canal being one foot greater than the depth of the other, let us examine what will be the comparative resistance of the boat being immersed 4 feet into the 48-foot canal, and but 3 feet in the other. We find in this case the ratio to be 1.47 to 1.58, or 100 to 107, and we infer from it that, with a gain of about 7 per cent. of towing-power, the weight transported on the 48-foot canal will be one-third greater than the weight transported during the same time on the 40-foot canal.

The foregoing considerations show that in determining the transverse section of a canal of great length, and with a dividing summit-level, the amount of lockage must have a due influence upon the breadth and depth of the water-section. And, indeed, taking into view the great distance and considerable lockage belonging to the present case, a cross-section larger than that recommended might have been suggested had not a regard to economy and to a competent supply of water during the dry season forbidden it.

However, the transverse section, as just proposed, may be deemed sufficient to fulfill in a satisfactory manner the main requisite for which it has been intended. And in order to remove all doubt, let us compare as to amount of transportation the contemplated Chesapeake and Ohio Canal with another of the same length, but whose lockage would be 600 feet only, with a transverse section of 40 feet at the surface and 4 feet in depth.

The rate of traveling being supposed for both two and one-half miles per hour, and one minute allowed for each foot of lockage, 60 feet will be, as to time, equivalent to two and one-half miles, and these canals will then compare as follows:

The Chesapeake and Ohio Canal having 3,158 feet of lockage in a distance of three hundred and forty-one and three-quarter miles, is equivalent, as to time, to a single

level canal of four hundred and seventy-three miles, which would require 189 hours to be traveled from one end to the other.

The 40-foot canal having 600 feet of lockage in a distance of three hundred and forty-one and a half miles, is equivalent, as to time, to a single level canal of three hundred and sixty-seven miles, and which would be traveled in 146 hours from one end to the other. But it has been shown that on the first canal the amount of transportation being expressed by 130, it will be 100 on the 40-foot canal—the velocity and towing power remaining the same in both cases. Comparing, now, this ratio of 130 to 100 with that of the time employed to travel respectively each canal, viz, 189 hours to 146, it is found that these ratios are equal. Therefore, on either of these canals, and notwithstanding a difference of 2,558 feet lockage, an equal weight will be transported during the same time, and with an equal towing power—a result entirely due to a larger transverse section having been assigned to the canal whose lockage is greater.

With a view to augment still more the amount of transportation without increasing the expense attending it, the boat might have received a length of at least eight times its breadth; but it would have required a length of lock of 118 feet, (between the hollow quoins,) which, on account of the great number of locks, would have caused too great an expense. The necessity of conciliating economy with the object to be expected from the work has, therefore, obliged us to limit the length of the boat to seven times its breadth, 13½ feet—that is to say, to 94 feet about; this length varying, however, from 90 to 94 feet, according to the mode of constructing the boat. With a draught of 3 feet, such a boat, if rectangular, would displace about 100 tons weight of water, or, on account of deviation from this form, about 90 tons only, it will carry a burden of 60 tons. Respecting the locks destined to admit this boat, they must have at least 102 feet between the hollow quoins, and 14 feet breadth in the clear. In the estimate, they are nearly all supposed to be of 8 feet lift, though in the framing of a final plan they should vary according to considerations not immediately connected with the object of the present report.

The sheet No. 3 exhibits the plan and sections of the lock upon which has been made the estimate of this article of expense. The main walls are built of common range-work masonry, (No. 18;) their facing only is laid with water-line cement. Hewn stone has been used exclusively for the hollow quoins, mitre-sills, abutments, and recesses of gates. The blocks do not exceed 9 cubic feet, (Nos. 27 and 28.) The bottom of the chamber consists chiefly of a reversed arch, built of brick, with water-line cement.

The estimate amounts to \$13,069.80. But we must take into consideration that a number of locks will have their foundation upon solid rock, and will therefore require less masonry; and also that owing to the necessary declination, which, in the final plan, the bottom of the canal will receive, the amount of lockage will be less than it is in this general plan. Under these impressions, \$12,000 has been deemed a fair average cost of a lock on the whole line of canal.

Respecting the aqueducts, they are to be built of masonry, and their lengths calculated to afford a free passage to the streams at the time of freshets; they are generally to be connected with the sides of the valley by means of embankments carefully made.

We now pass to the description of the canal.

EASTERN SECTION.

[Omitted.]

MIDDLE SECTION.

This section includes the summit-level, and extends from Cumberland (or rather from the western end of the eastern section) to the mouth of Castleman's River, in the Youghiogheny. Its length is seventy miles 1,010 yards; but a lockage of 1,961 feet and a tunnel of four miles 80 yards long, under a ridge of 856 feet elevation, will make this section extraordinarily expensive.

This section will, besides, require the erection of dams across the valleys through which it passes, and more especially in the bed of Will's Creek. This stream, in fact, affords, in summer and fall, a too small supply of water toward its sources to rely altogether upon it; the summit-level must feed, therefore, the upper portions, while frequent dams erected across the valley will make available the water delivered by the stream.

The valleys of Will's Creek and Castleman's River being formed of a succession of flats and bluffs, the canal will often require to be supported by walls whose height should place the work out of reach of the freshets. These freshets rise in Will's Creek from 7 to 10 feet, and from 12 to 16 feet in Castleman's.

In planning this section, care has been taken to avoid, as much as practicable, expensive aqueducts, and none is to be erected over Castleman's River. The canal will

follow constantly, the right side of the valley, whose southern exposure will procure an earlier navigation in spring and later in autumn. Respecting Will's Creek, its valley is so narrow at some places, and the height of freshets so inconsiderable, that four crossings have been made to take advantage of the most favorable ground, and thus lessen the expense. It must be observed that these two streams are not navigable, and will, therefore, require no peculiar work to accommodate their trade and navigation.

The execution of the tunnel will be not only very expensive, but also long and difficult; all the geological appearances lead to the conclusion that the excavation will have to be made through sandstone rock. The estimate has been calculated for three different kinds of ground, hard clay, sandstone, granite, and unstratified limestone. The hypothesis of sandstone being admitted here, the estimate relating to this kind of ground accompanies the present report. (See sheet No. 5.) The tunnel will require to be lined with masonry, experience having shown that this precaution is indispensable. Brick masonry has been adopted in the estimate as the most convenient to fulfill the object. The dimensions of the interior of the tunnel are, 22 feet in width, 7 feet under the water-line and 16½ feet above the same line, which form 23½ feet from the bottom to the top of the arch. The tow-path is 4 feet wide. The shafts destined to facilitate the excavation, and to air the tunnel, are proposed to be sunk 180 yards apart from center to center. Their diameter will be 6 feet within the lining of brick masonry. A gallery, lateral and parallel to the tunnel, corresponds with the shafts. This gallery, or heading, is destined to drain the tunnel during its excavation; its width is 3 feet, and its height 6½ feet; it is lined with brick masonry, and communicates with the tunnel by means of arcades or side-headings, which correspond to the points at which the shafts terminate into the heading. The sheet No. 4, herewith annexed, exhibits all the draughts relating to this tunnel, and to the deep cuts at its ends.

The deep cut at the western end is 1,060 yards long; that at the eastern, 140 yards; each opens into a basin having 880 yards in length and 64 yards in width. The tunnel, the deep cuts, and the basins, form together the summit-level, whose length will be 5 miles 1,240 yards; a lock is located at each end, and where each basin terminates.

Let us now examine the resources upon which we can rely to supply with water this summit-level, and the portions of canal contiguous to it. The stream upon which we have chiefly to depend is Castleman's; it yielded in 1825 and 1826 the following results:

	Cubic ft.
June 21, 1825, at Plencher's farm, per second	18
July 10, 1825, below Flaugherty's Creek	38
July 12, 1826, at its mouth	46
March 1, 1826, at Plencher's farm	98
March 27, 1826, below Flaugherty's Creek	715
March 21, 1826, at Forney's mill-dam	536

We have admitted, in the former part of the present report, 18 cubic feet per second as the minimum of water yielded by Castleman's River; and we have also pointed out two reservoirs, one at Pleucher's farm and the other at Forney's mill, containing together 22,000,000 cubic yards. These are the resources afforded by the localities to feed the summit-level and supply its lockage and also portions of canal contiguous to the summit-level.

The reservoirs are to be filled in winter, during the interruption of the navigation—an interruption which, considering the elevation of the summit-level above the ocean, 1,903 (†) feet, cannot be supposed less than four months, viz.: from the 1st of December to the 1st of April. By adopting 98 cubic feet per second as the mean supply afforded in winter by Castleman's River, at Pleucher's farm, we find that in less than seventy-two days both reservoirs would be filled up.

However, to remove any doubt on the subject, we will take an area of thirty-six square miles of ground whose rain-water supplies Castleman's River, and make a computation of what such an area would yield; we will suppose it to be formed of two strips of land, each of eighteen miles long and one mile wide, and stretching along the banks of Castleman's River above Forney's mill.

From observations made from 1817 to 1824, inclusively, by Mr. Lewis Brantz, in the vicinity of Baltimore, we have the following results: In the course of these eight years there fell, on a mean average, yearly, 39.89 inches of rain; in 1822 there fell the smallest quantity, which was 29.20 inches; the greatest quantity fell in 1817—it amounted to 48.55 inches.

Adopting these data for the country round the summit-level, and using only the results of the year 1822, we find that the rain which fell in the three first and three last months of said year amounted to 16.70 inches, and for the six other months to 12½ inches.

	Cubic yards.
These 16.70 inches are equivalent per square-yard surface to	0.463
The 12½ inches are equivalent per square-yard surface to	0.347
The whole, or 29.20 inches, are equivalent per square-yard surface to	0.810

Applying now these last results to the area of thirty-six square miles above mentioned, we find that they will receive at the minimum :

	Cubic yards.
During the fall and winter.....	51, 630, 796. 90
During the spring and summer	38, 695, 219. 90
The whole year round.....	90, 326, 016. 90

From which it will be seen, first, that the two-thirds of the first quantity, or 34,420,531 $\frac{2}{3}$ cubic yards, would be about one-third more than will be necessary to fill up the reservoirs in four months; second, that 44 cubic feet per second would make up, during six months, the two-thirds of the second quantity, and might, therefore, be deemed the mean discharge per second of Castleman's River during spring and summer, instead of 18 cubic feet, assumed in the present report; third, that this surplus will partly replenish the reservoirs during the time of navigation.

If to these considerations we add that, instead of thirty-six square miles, we might easily have taken double, we may conclude that, the filtrations and evaporations of rain-water being taken into the most liberal account, the portion of Castleman's Valley above Forney's mill will convey to the bed of this river more water than we have admitted; we believe, therefore, that the minimum supply of the summit-level will consist of, first, a reservoir of 22,000,000 cubic yards; second, 18 cubic feet per second of running water. And, since the navigation is supposed to be opened during eight months, the monthly resources will be 2,750,000 cubic yards from the reservoirs, 1,728,000 cubic yards from the river itself; total, 4,478,000 cubic yards per month. Let us see now how the use of this monthly supply will be regulated. Taking into consideration the unavoidable delays at the end of the summit-level, the impediments at the debouches of the tunnel and through the deep cuts, and, finally, the greater resistance the boats will meet through the tunnel, we cannot suppose less than 3 hours and 25 minutes for a boat to pass from one end of the summit-level to the other, which comes to one and two-thirds miles per hour. But the passage is to be effected in fleets or trains, on account of economy both of time and water; and we adopt thirty boats for each train—a number which in the present case seems to us favorable to combine the time of passage with the supply of water during the same time. These thirty boats, moving in train, will meet with more delay than would a single boat, and instead of 3 hours and 25 minutes, as before stated, we assign 4 hours to the train to pass from one end to the other of the summit-level.

We suppose, also, that a fleet of thirty boats, descending the eastern lock of the summit-level, and (through the same lock) passing an ascending fleet of the same number of boats, will effectuate this cross-passage in eight hours, under the plausible supposition that 16 minutes will be required for the cross-passage of a boat ascending and one descending. A similar cross-passage is supposed to take place at the western lock of the summit-level, and at the same time.

Now, a first fleet leaving the eastern lock will arrive four hours afterward at the western lock, and meet there a fleet coming from the west, and ready to proceed eastward. This second fleet will reach in four hours the eastern lock, and find there a third fleet, having ascended the lock during the passage of the first and second fleets. This third fleet will proceed westward, and arrive four hours after at the western lock, where it will find a fourth fleet, having ascended the lock during the passage of the second and third fleets. Lastly, this fourth fleet will move eastward and reach in four hours the eastern lock, meeting there with a fleet from the east, having ascended the eastern lock during the passage of the third and fourth fleets.

The passages of these four fleets, forming together 120 boats, and requiring four hours each, may be considered, as will be seen just now, the maximum of trade which the supply of water can admit. At this rate of 120 boats a day, 3,600 might pass per month, and 28,800 during the eight months of open navigation.

Let us now compute the expanse of water which the lockage of these boats will require. Admitting, as in fact will be the case, that, at each lock, one ascending boat alternates with a descending one, each boat will draw, from the summit-level, but one lockful, viz., half a lockful at each end. However, in order to provide for contingencies and unforeseen cases, we adopt one lockful and a half for the passage of each boat through the summit-level. One lockful and a half containing 623 cubic yards, the 3,600 boats passing during one month will require 2,242,800 cubic yards of water, which, being taken out of the monthly supply, amounting to 4,478,000 cubic yards, will leave 2,235,200 cubic yards. This last quantity is destined to feed the canal itself, exclusive of lockage, on a length of 18 miles and at a rate of 120,000 cubic yards per mile and per month, absorption, filtration, and evaporation being taken into account. These eighteen miles comprehend the summit-level, a portion of six miles in Will's Creek, and a similar of also six miles in Castleman's Valley. The remainder of the canal down Will's Creek will be supplied by this stream, while Castleman's River will feed the remainder of the canal descending its valley.

The estimated cost of the summit-level, just described, is as follows :

The tunnel—	
Shafts	\$233,032 95
Heading	383,534 83
Side heading	7,704 27
Tunnel	2,495,242 80
Draining	159,469 20
Total cost of tunnel	3,278,984 15
The eastern basin	26,741 14
The eastern deep-cut	18,733 00
The western deep-cut	141,840 72
The western basin	5,668 00
Total estimate of the summit-level	3,471,967 01

The details relating to the estimate of the tunnel are exhibited in the sheet No. 5, annexed to this report. As to the basins and deep-cuts, their detailed estimates have been carried into those belonging to the eastern and western portions of this middle section. We shall now present successively the description of these portions: the eastern, commencing at the eastern end of the summit-level and terminating below Cumberland; the western, beginning at the western end of the summit-level, and debouching into the Youghiogheny below the mouth of Castleman's River.

EASTERN PORTION.

Subdivision 1.—From the eastern end of the summit-level to the mouth of Little Will's Creek :

Distance, 15 miles 460 yards; descent, 1,016 feet; 127 locks.

The canal follows for $8\frac{1}{4}$ miles the left side of the valley of Will's Creek; it then crosses the stream to descend for two miles along the right bank; crossing again the creek it remains on the left side as far down as the fourteenth mile; it then crosses a third time, to follow the right side of the valley as far down as opposite the mouth of Little Will's Creek.

The considerable descent in so short a distance, the contracted breadth of the valley, the steepness of its sides, the great quantity of excavation in rocky ground, will concur together to render this subdivision very expensive in proportion to its extent.

The distance between the heads of two consecutive locks will not be less than 180 yards. The first six miles will be fed, as stated before, by the summit-level; the remainder will be supplied by Will's Creek. To that effect dams, erected at suitable places, will afford the means of taking into the canal not only the waters of the creek, but also those of its tributaries.

The estimate of this subdivision amounts to (the eastern basin and deep-cut excluded) \$2,300,859.28.

Subdivision 2.—From the mouth of Little Will's Creek to the western end of the eastern section, below Cumberland :

Distance, $13\frac{1}{4}$ miles; descent, 309 feet; 39 locks. From the summit-level, twenty-nine miles 240 yards; descent, 1,325 feet; 166 locks.

At the commencement of this subdivision the line of canal takes a sudden change of direction from nearly east and west to almost north and south. The valley also changes its character, becoming broader, more level, and less rapid in its descent.

The canal continues for ten and one-half miles on the right bank of the stream, passing alternately along steep and rocky hill-sides and through meadow-land, but even in the latter requiring a large quantity of excavation of rock. It then passes over to the left bank, and continues for more than half a mile on favorable ground, when it enters the defile formed by the breaking of Will's Creek through the mountain of the same name.

The difficulties of this passage are great, and continue for more than a mile. The ground then becomes favorable, permitting the canal to pass at the outskirts of Cumberland, to join with the eastern section.

Provision is made for taking in a supply of water immediately below the junction of Great and Little Will's Creeks, and also at several points below. Adjoining Cumberland, the canal will receive a feeder from the Potomac for a supply below, and more especially to complete what is necessary in relation to the first subdivision of the eastern section.

This feeder is proposed to be made navigable, in order to accommodate the trade of the Potomac above Cumberland. Its length is one mile; its width, at the water-line, 30 feet; its depth, 4 feet. At its point of departure from the Potomac a basin is formed in the bed of the river, by means of a dam erected at the first ledge above.

Cumberland. This basin, comprehending an extent of about eight miles, will afford a constant supply of water, and also accommodate the coal-trade of the Potomac. The levees around the basin, the dam, the guard-lock of the feeder, the feeder and its aqueduct over Will's Creek, are included in the estimate of this subdivision.

A basin is contemplated at Cumberland, and adapted to the probable wants of the place; it will be provided with locks to communicate with the Potomac.

The estimate of this subdivision amounts to \$1,555,764.32. The estimate of the eastern portion amounts to \$3,856,623.60.

WESTERN PORTION.

Subdivision 1.—From the western end of the summit-level to the mouth of Middle Fork Creek:

Distance, 16½ miles; descent, 216 feet; 27 locks.

This subdivision commences at the western end of the basin formed in the valley of Flaherty's Creek, and into which is introduced the feeder from the reservoirs in the valley of Casselman's. Having already stated all the details relating to this appendage of the summit-level, we find ourselves dispensed from entering into further explanation upon the subject.

The canal for this subdivision is on the right bank of Casselman's River. On this distance, although no very formidable difficulties are presented, yet the amount of excavation of rock, as also the great quantity of walling, will render the work very expensive. The first six miles are to be fed by the summit-level, as it has been stated; as to the remainder, provision has been made, at several places, for taking from Casselman's River additional supplies.

It is to be observed that this upper subdivision of Casselman's River has a descent less rapid than that of the lower; the reverse takes place in the valley of Will's Creek.

The estimate of this subdivision amounts to (the western basin and deep cut excluded,) \$1,240,215.32.

Subdivision 2.—From the mouth of Middle Fork Creek to the mouth of Casselman's River:

Distance, 19 miles 1,030 yards; descent, 420 feet; 53 locks. From the western end of the summit-level, 35 miles 1,250 yards; descent, 636 feet; 80 locks.

This subdivision keeps on the right bank of Casselman's River, as far down as 440 yards below its mouth. The nature of the ground through which it passes resembles that of the subdivision above, except in the vicinity of the Youghiogheny, when it becomes much more favorable, offering more earth and less rock for excavation than above. Occasional resorts to the stream will secure to the canal a competent supply of water. And at the end of this subdivision, two feeders, one from Casselman's River and the other from Laurel Hill Run, are introduced for the supply of the section descending the valley of the Youghiogheny.

According to the documents hereto annexed, the estimate of this subdivision amounts to \$1,459,316.93. And the estimate of the western portion amounts to \$2,699,532.25.

We close the description of the present middle section by offering the following summary of the main facts relating to it:

	Distances.		Ascent and descent.	Number of locks.	Estimate.
	Miles.	Yds.	Feet.	"	
Eastern portion	20	240	1,335	166	\$3,256,623 60
Summit-level	5	1,280			8,471,567 61
Western portion	35	1,250	636	80	2,699,532 25
Total	70	1,010	1,961	246	10,028,123 86

WESTERN SECTION.

This section commences 440 yards below the junction of Casselman's River with the Youghiogheny; it follows the right side of the valley to the Monongahela, and hence to Pittsburg, along the right bank of this stream.

The ground on the left of the Youghiogheny is nearly of the same kind as that on the right; the distance and descent the same for either bank; however, the right bank deserves the preference on account of exposure, and of its receiving the main tributaries of the stream; it will not require, across the Youghiogheny, two aqueducts, which would otherwise become indispensable, should the canal follow the left side of the valley.

This section will be supplied with water by the Youghiogheny and its tributaries; and since the eastern end must rely chiefly upon the Youghiogheny, Casselman's River, and Laurel Hill Run, we will first present the results of the gauging of the streams, made in 1825 and 1826, during the month of July:

	Cubic feet.
Casselman's at its mouth, July 20, 1825, per second	40
Laurel Hill Run at its mouth, July 20, 1825	7
Youghiogheny River, above the mouth of Casselman's, July 21, 1825	70
Cubic feet per second	117
Cas-el-man's at its mouth, July 20, 1826, per second	46
Laurel Hill at its mouth, July 20, 1826, per second	26
Youghiogheny River, above the mouth of Casselman's, July 20, 1826	104
Cubic feet per second	176

These results, though obtained at a time of low-water, yet cannot be deemed as the minima of what these streams can afford; when measured they were not at their lowest stage. Therefore, we assume but 70 cubic feet per second as the minimum of water yielded by these three streams taken together, at the driest epoch of the year.

The Youghiogheny gauged at other points has given, in 1825, the following results: July 28, at the Ohiopyle Falls, per second, 155 cubic feet reduced to 100 cubic feet.

August 2, at Connellsville, per second, 129 cubic feet reduced to 100 cubic feet.

September 2, at its mouth, per second, 260 cubic feet reduced to 150 cubic feet.

The stream, though very low when measured, was not, however, at its lowest stage; but the season was uncommonly dry, and the above reductions may be considered as minimum.

To these resources of running water we must add the following reservoirs:

	Cubic yards.
Indian Creek	210, 370
Monutz's Creek	323, 889
Jacob's Creek	356, 857
Big Sewickly Creek	1, 750, 180
Dunbar	214, 464
	2, 855, 760

To which may be added the reservoirs which might be formed in Casselman's River and Laurel Hill Run Valleys.

We must remark that the feeders from all these reservoirs will be very short, their length varying from half a mile to four miles only.

Having pointed out the means upon which we have full reliance to feed this section of canal, we shall show their distribution at the same time as we describe the successive subdivisions of said sections.

Subdivision 1.—From the western end of the middle section to Connellsville:

Distance, twenty-seven and one-half miles; descent, 432 feet; 54 locks.

This subdivision begins about one-quarter of a mile below the mouth of Casselman's River. The bottom of the canal is placed here 4 feet above the level of low-water in Casselman's River, in order to afford the greatest advantage in taking a feeder from this stream, and also in using the most favorable ground below.

In the course of the first three miles the ground becomes gradually more difficult until it assumes the rocky and steep appearance which is so peculiarly the character of the Youghiogheny in so many parts of its upper course. To this difficulty of the ground must be added those arising from the necessity of keeping the canal above the freshets, whose elevation varies from 13 to 16 feet.

The ground continues unfavorable as far down as the old salt-works, seven miles from the beginning of this subdivision, where the line pursues, for a short distance, some favorable ground; but it becomes almost immediately thrown upon a steep hill-side covered with loose rocks, and which continues for three miles further to Ohiopyle Falls.

These falls form one of the most remarkable features of the Youghiogheny, and are formed by the river breaking through the rocky base of the ridge of Laurel Hill. The difficulty it has found in forcing this obstacle is plainly indicated by the sudden bend which the river here makes and the rough appearance of the channel it has carved out. It is most fortunate that the line of canal can, by means of a moderate cut, 283 yards long and 18½ feet deep, avoid pursuing the bank of this rugged channel. This deep cut across the neck of the bend of the river has, besides, the advantage of shortening the line by one mile and a half.

A feeder is proposed to be taken from the river a little above the falls, for which the

localities are very favorable; but the line of canal, by pursuing the most advantageous ground, has to descend, within the short distance of one mile, 96 feet; which circumstance will oblige to locate the locks too near to each other for preventing ponds of sufficient extent between them. Several plans suggested themselves to obviate this inconvenience: first, to have the intervening ponds sufficiently wide to admit the easy passage of two boats at once, and to supply these ponds and the locks by means of a waste-way parallel to their course; second, to have lateral reservoirs to receive the contents of adjoining locks, and to transmit it respectively to the second lock below; third, to make the ponds liable to have the level of their waters varied from 2 to 3 feet, and thus making them perform the functions of locks. A close examination, when locating the line, will determine which of these means deserves the preference. The two first will cause a greater consumption of water than usual, but as a feeder is to be immediately introduced above for the purpose of supplying the next level below, this consumption is not, in this case, to be taken into consideration.

Below the Ohiopyle Falls the ground continues difficult for about nine miles to Indian Creek. On this distance the canal is mostly to be carried along a steep bank, in part supported by walls, and excavated through rock. The descent is also rapid, being about 160 feet, and requiring 20 locks. Indian Creek is to be crossed by an aqueduct; it will afford a valuable supply of water, for securing which a feeder and reservoir are proposed.

The ground from Indian Creek to Connellsville, seven miles, is still difficult, but more varied in its character than above; it will necessitate alternately steep hill-side cutting, much of which is rock, and some expensive walling, interspersed with some pieces of moderate cutting.

A basin is proposed at Connellsville, on the level of the canal, for the accommodation of the trade of this place; its communication with the river is established by means of locks.

This subdivision is supplied with water by the Youghiogheny above the mouth of Casselman's River, by Casselman's River and Laurel Hill Run. At the Ohiopyle Falls it receives a new supply from the Youghiogheny; at Indian Creek it will also, when necessary, receive a supply from the reservoir formed above the mouth of this creek. From the detailed estimate, hereto annexed, the estimated cost of this subdivision amounts to \$1,515,436.59.

Subdivision 2.—From Connellsville to Sewickly Creek :

Distance, twenty-seven and one-fourth miles; descent, 144 feet; 18 locks. From the beginning of the section, fifty-four and three-fourths miles; descent, 576 feet; 72 locks.

Before arriving at Connellsville the line may be said to have completely passed the range of the western ridges, and the face of the country undergoes an entire change. The banks of the river, however, do not so suddenly lose the character they bear above, but it continues to offer a succession of similar, though gradually decreasing, difficulties for some distance below. This subdivision will, therefore, like the portion above Connellsville, require, for almost its whole distance, steep side-cutting and walling alternately; it will, consequently, be expensive.

Mountz's Creek, one mile, and Jacob's Creek, seventeen miles, below Connellsville, will afford a valuable supply of water for this subdivision; but a resort to the river is still considered necessary, and provision is made to effect this a little below Mountz's Creek.

The two creeks hereabove mentioned are to be crossed by aqueducts, which, owing to the great breadth of the valleys, will require, at their ends, considerable embankments.

The estimated cost of this subdivision amounts to \$1,306,425.95.

Subdivision 3.—From Sewickly Creek to the mouth of the Youghiogheny :

Distance, sixteen and a half miles; descent, 8 feet; 1 lock. From the beginning of the section, seventy-one and a quarter miles; descent, 584 feet; 73 locks.

This subdivision offers a larger portion of easy cutting than the preceding, but will still require a large portion of side-cutting and walls to pass round the bluffs. These subdivisions are numerous and though none individually is of great extent, yet they form together a length of several miles of expensive works.

As McKeesport is at the junction of the Youghiogheny and Monongahela, a basin is proposed there for the accommodation of the trade of the latter stream.

The only lateral supply of water for this subdivision is from the reservoir above the mouth of Sewickly Creek, and it becomes necessary to resort to the Youghiogheny again in order to meet the deficiency which otherwise would be felt on the subdivision to Pittsburgh. To fulfill this object, a dam is proposed across the Youghiogheny at a favorable point three miles above its mouth. This dam will require a considerable height, and therefore locks must adjoin it, that the navigation of the stream should not be injured by the works of the canal, but rather be benefited by them.

The estimate of this subdivision amounts to \$741,469.54.

Subdivision 4.—From the mouth of the Youghiogheny to Pittsburgh :

Distance, fourteen miles ; descent, 35 feet ; 5 locks. From the beginning of the section, eighty-five and one-quarter miles ; descent, 619 feet ; 78 locks.

This subdivision is generally located through favorable ground ; however, some side excavation will still be necessary, and a deep cut near Pittsburgh, of about three miles in length and 15 feet of average depth, is indispensable, to avoid a line yet more difficult and expensive.

This subdivision is almost entirely dependent on the Youghiogheny above McKeesport for its supply of water ; the streams crossed by the canal afford so little water during the dry season that no reliance can be placed upon them.

According to the documents hereto annexed the estimate of this subdivision amounts to \$606,891.60.

Summary of the western section.

Distance, miles.....	85½
Descent, feet.....	619
Number of locks.....	78
Estimate.....	\$4, 170, 223 78

Here ends the description of the several sections of the Chesapeake and Ohio Canal, and whose general summary is as follows :

Sections.	Distance.		Ascent and descent.	Number of locks.	Amount of estimate.
	Miles.	Yds.	Feet.		
Eastern.....	185	00	578	74	\$8, 177, 081 05
Middle.....	70	1, 010	1, 961	246	10, 028, 128 86
Western.....	85	440	619	78	4, 170, 223 78
Total.....	341	1, 450	3, 158	398	22, 375, 427 69

The foregoing description shows that the Chesapeake and Ohio Canal presents nearly all the characteristics which contribute to render a work of this kind very expensive, viz. an extraordinary amount of lockage, a long tunnel, passing under a very elevated ridge ; walling unusually frequent along the whole line ; extensive portions of deep cutting, excavation of rocky ground and side-cutting, predominating from one end of the canal to the other. The tunnel and lockage alone form together four-elevenths of the whole expense, and if, from the total estimate, we take out the tunnel and reduce the lockage to 1,200 feet, (which may be deemed an unusual amount for such a distance,) the estimate would then amount to \$16,000,000 only, notwithstanding the other difficulties to be overcome and the accommodation of trade along the valleys of the Potomac and Youghiogheny.

We will also observe that the middle section alone, whose length is but seventy miles, or one-fifth of the whole length of the line, will cost (according to the estimate) \$10,000,000, or the five-elevenths of the whole expense, while the eastern and western sections, whose lengths form together the four-fifths of the whole, will cost but \$12,000,000, or the six-elevenths of the whole estimate.

We consider, however, as fortunate that these two expensive articles, extra lockage and tunnel, should be found both located upon a section which, after new investigations and mature reflection, might prove to be advantageously superseded by a railway. Indeed, the inexhaustible mines of coal found in the lower parts of the valleys of Will's Creek and Casselman's River seem to point out to us, as a means to avoid this expensive middle section, the expediency of a railway, with either locomotive-engines or stationary steam-engines, used as lifting-power.

We must also observe that this section will be wanted, but after the completion of the eastern and western sections, which two last being in Washington and Pittsburgh, within seventy miles of land communication, would soon point out, by their results, what should be the most expedient mode of connecting them. Perhaps, then, a smooth road, with an easy graduation, would, at first, be resorted to from the mouth of Casselman's River to Cumberland ; or, should a great amount of trade warrant it, a railway might be adopted. In this latter case, which we deem the most probable, the revenue of the eastern and western sections would not only afford the usual interest of the capital employed in their construction, but also have a surplus fund with which a railway might be erected.

Therefore, we are decidedly of opinion that for the present the expense relating to the eastern and western sections ought exclusively to be taken into consideration ; that the sum of about \$12,000,000, to be expended for their construction, will create the means and afford the resources to procure to the work the mode of completion most adequate to its object.

Our instructions being to plan a canal from tide-water in the Potomac to the head of steamboat navigation in the Ohio River, we had not to take into consideration either

railways or any other substitute for the difficult and expensive sections of the canal; therefore no operations in the field, no investigations in the closet, have been made in relation to such an alternative. And, indeed, had even our instructions demanded such inquiries, the want of time and the limited means at our disposal would have prevented us from bestowing upon the subject the full and mature consideration to which it is so deservedly entitled. However, we do not hesitate anticipating that a railway from the mouth of Casselman's River to Cumberland will bear, as to expense and time, a favorable comparison with the middle section above described.

We recommend, therefore, for a canal from tide-water in the Potomac to the head of steamboat navigation in the Ohio the route and plan hereinabove described; and we submit respectfully to consideration the expediency of making the surveys and investigations necessary to ascertain, as accurately as practicable, the comparative merits of a railway and a canal for the section of route from Cumberland to the mouth of Casselman's River.

ADDITIONAL SUBDIVISION OF THE EASTERN SECTION OF THE CHESAPEAKE AND OHIO CANAL FROM THE MOUTH OF SAVAGE RIVER TO CUMBERLAND.

Distance thirty miles 350 yards; descent, 312 feet; 39 locks.

The canal for this subdivision remains on the left bank of the Potomac. This plan was adopted after an attentive consideration of the relative advantages and disadvantages of passing the river several times to follow the best ground. But to do this such frequent crossings would be necessary, and attended with so many inconveniences and risks, that this project was deemed the less expedient.

As the object of this subdivision is to attain the coal-mines near Savage River, it was considered whether this might not be attained by a canal of smaller dimensions and less perfect than the main line below; the result of which was that the dimensions and plan of the original canal were adhered to. For, first, it was found, on applying the calculations to the ground, that a very trifling decrease of expense would be made by decreasing materially the dimensions of the canal; and, second, the unfavorable character of the river to a lock-and-dam navigation, which was thought of as a substitute, rendered this scheme almost as expensive, and much inferior in usefulness to the independent canal.

The subdivision begins by a basin formed in the Potomac by a dam, immediately below the mouth of Savage River. The line immediately enters on a most difficult piece of ground, which continues more than half a mile; another half mile is then favorable, after which it continues difficult for three-fourths of a mile, to Westernport. It then becomes favorable, with the exception of several small portions, to the end of the seventh mile, when the great bend of the river, opposite to Paddy Town, causes the ground to become very rugged and difficult for a space of two miles. Below this, for three miles, the favorable ground is intersected by only small portions of rock side. For the ensuing five miles the approach of Fort Hill to the river presents alternately some easy ground, but a large portion of very difficult nature, requiring much walling and excavation of rock. Below this the ground is favorable for three miles, through Cressap's meadow, when difficulties again occur for two miles. The remaining distance to Cumberland is favorable, with the exception of three portions, which are not of very great extent, but which will require extensive works. An aqueduct over Will's Creek will be necessary.

About eight miles above Cumberland it is proposed to place a dam across the river, and to use its water not only for the supply of the lower part of this subdivision, but also of that below.

BERNARD,
Member of the Board of Internal Improvement.
WM. TELL POUSSIN,
Captain Topographical Engineers, and Assistant to the Board.
W. HOWARD,
Civil Engineer, Assistant to the Board.

ABSTRACT OF ESTIMATE.

1,336,618 cubic yards excavation, (18 to 88 cents per yard).....	\$339, 441 46
562,000 cubic yards embankment, (20 cents per yard).....	113, 257 60
210,931 cubic yards walling, (\$3.50 per yard).....	720, 655 20
2 aqueducts, (3 arches and 2 arches).....	66, 277 00
41 locks of 800-foot lift, (\$12,000 each).....	492, 000 00
34 culverts.....	10, 200 00
12 bridges.....	4, 200 00
Puddling.....	31, 722 00
Fencing.....	16, 200 00
2 waste-weirs.....	1, 000 00
Total	1,794, 963 26
Or 30½ miles, at \$59,435 per mile.	

Appendix B.

REPORT ON THE SALISBURY SOMERSET COAL-BASIN, BY J. P. LESLEY, PROFESSOR OF GEOLOGY, UNIVERSITY OF PENNSYLVANIA.

Somerset County, in southwest Pennsylvania, borders on Maryland.

Salisbury and Berlin are towns in its first sub-coal-basin back of the Alleghany Mountains; Ursina and Confluence are in next sub-basin west of Negro Mountain; Ligonier Valley holds the second bituminous coal-basin, and lies west of Laurel Hill. Connellsville and Blairsville, west of Chestnut Ridge, mark the east outcrop of the third, fourth, fifth, and sixth bituminous coal-basins, extending unbroken into the State of Ohio.

The basin of the upper or Salisbury coals extends about nine miles, from near Meyer's mills, at its north end, to just over the Maryland line.

The lower coal-beds, with which we will have less to do, spread down from the top of the Alleghany Mountains under the whole of Somerset County, excepting only the summit of Negro Mountain and the crest of Laurel Hill.

The upper coal-beds, which give to the Salisbury Basin its exceptional importance, have been entirely swept away from the surface of Somerset County, except in two places: 1st, they remain in the long narrow ridge at Salisbury; 2d, they remain in the central part of the Frostburg or Cumberland Basin. They remain also in eastern Fayette County, in one little hill-top near Ligonier; and the Pittsburg bed has been left in like manner, on Broad Top, in Huntingdon County, under a few acres at the summit of the highest peak of that mountain. With these few exceptions, this bed has been washed, worn, or eroded from the whole surface of Middle and Western Pennsylvania, east of a line drawn through Connellsville and Blairsville. West of this line, and south of the Kishkaminitis and Ohio Rivers, the upper or Pittsburg coal series of beds have more or less escaped erosion, and are spread through western Fayette and Westmoreland Counties, and are mined everywhere along the rivers which flow with and into the Monongahela. At Ursina and Confluence we have only the lower coals. At Connellsville, Greensburg, and Pittsburg we have the upper coals, as also in the Salisbury Hills; also in the center of the Cumberland, George's Creek, or Frostburg coal-basin. The "Pittsburg Bed," the "Connellsville Bed," the "Irwin Gas-Coal Bed," the "Greensburg Great Bed," the big bed at Latrobe and Saltsburg, are all one and the same coal-bed; the same as the lowest of the three upper Salisbury beds, (about to be described,) the same as the George's Creek bed in the middle of the "Cumberland Basin."

This is the fact of first importance in a report on the Salisbury coal-basin. The fact of next importance is that the coal-bed above described becomes thin and poor toward Pittsburg and down the Ohio, but grows slowly and steadily in size and quality going east along the Pennsylvania Railroad, southeast along the Baltimore and Pittsburg Railroad, and south up the Monongahela.

At Pittsburg it is about 6 feet thick, and injured by pyrites and slate; at Irwin's and Monongahela City it is 8 and 9 feet thick, and a fine gas-coal; at Connellsville and Latrobe it is 11 and 12 feet thick, a noble bed for cooking-purposes. What it was in the country between Connellsville and Meyer's mills we do not know, but when we next meet a fragment of it at Meyer's mills, in the Salisbury ridge, we find it from 12 to 15 feet thick. And finally, in the Cumberland Basin it is 17 feet thick, and everybody knows its quality there by the annual consumption of from one to two millions of tons in Baltimore, Philadelphia, New York, and Washington, and on coastwise and ocean steamers. This is the bed which furnishes almost all the coke used at Pittsburg and the largest part of the raw coal of the Ohio River trade, and its quality is so superior that it has long monopolized the iron-making market at Saint Louis, Mo. This is the bed which furnishes almost all the coal to the gas-works of the seaboard cities and inland towns; and apropos of this circumstance—

The fact of next importance is that the percentage of gas yielded by the coal of this bed increases westward and decreases eastward. In the Pittsburg region it yields from 35 to 40 per cent. of volatile matter; at Blairsville, Latrobe, Connellsville, and Uniontown its average may be called 30 per cent.; in the Cumberland Basin it is sometimes as low as 17 per cent. Its average in the Salisbury Basin will, therefore, be somewhere above 20 per cent. and below 25 per cent.

(NOTE.—I have no trustworthy analysis of these Salisbury coals. One specimen was said to yield 29 per cent. volatile matter. The Ursina, Confluence, or Turkeyfoot lower coals under-run 20 per cent., and lie farther west.)

As we distinguish such coals as semi-bituminous, coals with only 10 to 12 per cent. as semi-anthracite, and coal with from 9 to 5 per cent. as anthracite, we may say (in the market) that the Salisbury coal (of this bed) belongs with the George's Creek Cumberland semi-bituminous steam-coals, the finest steam-coal, by the by, in the world

It has, however, a little more gas, and belongs properly also to the good coking-coals, with an advantage over the Connellsville part of the bed, not in the excellence of its coke, but in making 200 pounds more of coke from a ton of coal, viz, 10 per cent., or whatever else may be the proved difference between the average percentage of volatile matter in the coals of the two districts.

The next important fact to be noticed is that there are three other coal-beds overlying the Pittsburg-Connellsville bed, two of which are also preserved in the Salisbury Basin.

On Cheat River, in Virginia, the whole system of four beds is as follows:

	Feet.
Waynesburg coal-bed, from.....	6 to 9
Interval, (shales, sandstones, limestone,) from.....	183 to 207
Sewickly coal-bed, from.....	4½ to 6
Interval, (shales, sandstone, limestone,) from.....	40 to 49
Redstone coal-bed, from.....	4 to 5
Interval, (shales, sandstone, limestone,) from.....	18 to 6
Pittsburgh coal-bed, from.....	7 to 14

At Uniontown and Connellsville there are, in all, six beds, well marked, and separated from each other, thus:

	Feet.
Nameless coal-bed.....	—
Interval.....	18
Waynesburg coal-bed.....	1 to 3
Interval.....	120
Uniontown coal-bed.....	2
Interval (great limestone formation).....	130
Sewickly coal-bed, interval.....	5
Redstone coal-bed, very thin, interval.....	86
Pittsburgh coal-bed.....	14

In our Salisbury coal-basin we have as the highest rock on the hill-tops, the equivalent of the Waynesburg sandstone in the form of a massive conglomerate sandstone called (after its Kentucky name) the anvil-rock—black slate representing the Waynesburg coal-bed.

	Feet.
The upper limestone, black slate, and a little coal.....	20
Uniontown coal-bed, (coal and slate).....	50
The lower limestone.....	15
Sewickly coal, (upper Berlin, coal and slate).....	15
Interval.....	55
Redstone coal, (double bed).....	10
Interval.....	30
Pittsburg coal, (lower Berlin).....	11

Such was the section I made at Myer's mills, in September, 1857. In 1870 I got numerous sections along the southern or Salisbury portion of the basin, which show the usual variations both in the size of the coal-beds and in the intervals separating them, but prove the only fact of importance to us, that the Pittsburg bed maintains its predominant quantity and quality the entire length of the basin. They prove also the Sewickly bed is everywhere large, but not reliable in quality, being very slaty. They prove also that the redstone bed is persistent, but not an unusually large bed. They reveal, moreover, a new and important fact, that there is a valuable coal-bed underlying the Pittsburg coal-bed.

The section of the southern half of the Salisbury basin (upper) coal-measures may, therefore, be thus stated:

	Feet.
The great limestone Sewickly coal bed, (slaty).....	10
Interval, (soft shales).....	44
Redstone coal-bed.....	6
Interval, (shales).....	10
Pittsburg coal-bed, (with parting 2 feet).....	13
Interval containing two small coal-beds.....	64
Salisbury coal-bed, over.....	4
Thence down to the level of Casselman River.....	55

(Opened recently on the Jonas Beechy tract, 15 feet above river, 5½ feet of pure coal.

Although the Salisbury basin is only nine or ten miles long, and one or two miles wide, and cut by numerous short ravines, which make the outcrop of these beds follow zig-zag courses around the hill-sides, it will be seen at once, from the above sections, what

an enormous quantity of coal has been left in the ridge, and how perfectly accessible it is. I shall give quantities presently.

There lie beneath the river-bed, and conformable to the upper coal-measures just described, the following beds of the lower coal-measures. These have been struck in an oil-well boring as follows in depths from mouth of well:

	Feet.
Elk Lick coal, (called 4 feet thick,) at	96
Upper Freeport coal, (called 10 feet thick,) at.....	132
Lower Freeport (?) coal, (called 8 feet,) at.....	252
Black slate and coal, (mixed, 2 feet,) at.....	300
Johnstown ore-bed, at about.....	340
Streaks of coal, at about.....	480
Conglomerate, (forming crest of Alleghany Mountains).....	500
And continuing more or less to.....	640
Red shale of XI, hence down to bottom of well	690

These coal-beds of the lower system spread through the hills east of Casselman's River, and form the mineral riches of all the Berlin, Salisbury, Ursina, and Johnstown country; but they are hardly worthy of entering into our present discussion of the upper coal-beds of the Pittsburg (Salisbury) series, in the Salisbury Basin ridge.

The area occupied by the Pittsburg (Connellsville or Westmoreland) bed is eight and a half miles long; its greatest width is three miles, and the average width opposite Salisbury, and south of Tubmill Run, one mile.

QUANTITY OF PITTSBURG BED-COAL.

The sum total of 5,000 acres of coal-bed is got by deducting about 1,000 acres for loss by valley erosion, and indefinite southwest limit, from 5,955 acres of calculated total coal-bed area between Meyer's mills and the south end of the Salisbury Basin.

The whole area is subdivided naturally into four portions, thus:

	Per foot.
A 2,000 acres, which at 1,000 tons.....	2,000,000 tons.
B 2,200 acres, which at 1,000 tons.....	2,200,000 tons.
C 915 acres, which at 1,000 tons.....	915,000 tons.
D 840 acres, which at 1,000 tons.....	840,000 tons.

5,955 acres, which at 1,000 tons	5,955,000 tons.
Say 5,000	5,000,000 tons.
Allowing only 10 feet depth to the bed we get.....	50,000,000 tons.

NOTE.—The above estimate of 1,000 tons to the acre, for each foot thickness of bed, allows for pillars, slack and waste of all kinds, and represents the amount of coal placed in the cars outside.

The actual geological quantity of coal in this Salisbury (Somerset County) outlier of the great Pittsburg bed, must be nearly one hundred millions of tons.

QUANTITY OF REDSTONE-BED COAL.

The area of this bed is about one-half that of the great bed below it, and its average thickness is not so well known. I do not think it prudent to estimate for all its detached areas, ten in number, more than 15,000,000 tons, possibly gross contents 24,000,000 tons.

QUANTITY OF SEWICKLY-BED COAL.

Area about one-tenth of the Pittsburg bed; total of coal of all qualities, 5,000,000 tons. The above estimates are in *minimo*.

QUANTITY OF SALISBURY COAL.

The recent opening of this bed, $5\frac{1}{2}$ feet thick, at an elevation a few yards above the river-level, near the south end of the basin, is a matter of great importance. The coal shown to me in Philadelphia is of superb quality, although somewhat too prismatic to bear long transport. It appears to be as pure as the best George's Creek (Cumberland) coal, and must make first quality of coke. (See analysis at end of this report.) It outcrops all along the river-face and on both sides of Tubmill Run; and its total area must be at least one-half greater than that of the Pittsburgh bed, but I have reason to believe its thickness to be less at the north end than at the south end of the basin. (On Elk Lick Creek is a 4-foot bed of very good coal, but belonging to a lower geological position.)

The Salisbury coal-bed, if even 5 feet thick under the south end of the basin, will contain 25,000,000 tons, the most, if not all, of which lies above water-level. It is then proper to add to the above quantities a total available sum in this Salisbury bed of at least 20,000,000 tons.

QUANTITY OF COAL BENEATH WATER-LEVEL.

Future mining operations in the beds of the lower coal-measures will reveal their condition, thickness, and quantity. They underlie the whole area of, say, 9,000 acres, more or less, which is in question. It is perfectly safe to give two beds yielding 5 feet each, *i. e.*, to say 120,000,000 tons, or on a practical estimate, 90,000,000 tons.

As these lower beds can only be reached by shafts, and as they spread throughout Somerset County, and the upper beds are above water-level and monopolized by a few properties between Meyer's Mills and the Maryland line, it seems hardly worth while to introduce this secondary element into my estimate of the value of the Salisbury Basin, which is in itself, and entirely apart from the existence of these lower coal-beds, so extraordinarily valuable.

NOTE.—In any other coal-region of the world the existence of beds nearly horizontal, and to be reached by shafts less than 300 feet in depth, (see oil-well boring,) would of itself give great value to the overlying properties. My report on the Ursina lands shows that one bed struck by such a shaft is the fine 6-foot coal mined on the north fork of Casselman's River, on the west side of the Somerset Basin. Its analysis is a good deal like that of the Cumberland coal. This 6-foot bed is the great bed of Casselman's River, between Meyer's Mills, Confluence, and Ursina, and it is increasing in thickness eastward, so that the report of its being 10 feet thick under Salisbury (see oil-well boring) may very well be a true one.

I first became acquainted with the isolated and exceptional character of this bed in 1840, during my survey of Somerset, Fayette, and Cambria Counties, in company with James F. Hodge, and as assistant of the State geologist, in whose fifth annual report my sketch of the geology of the Salisbury Basin is embodied, but without details. My knowledge of its peculiarities was much enlarged in subsequent years, and impressed me always more and more. I have frequently urged its claim to special attention, but until the completion of the Connellsville and Cumberland Railroad connection no steps for its development could be profitably undertaken. This connection being now made nothing can prevent this Salisbury Basin from becoming a second, though somewhat smaller, Cumberland Basin, and that without any rival but the Cumberland Basin.

(No. 1.)—For the little hill-top patch of Pittsburgh bed left standing in the Ligonier Valley is entirely out of the way of all trade, and too minute in itself to be of any account; and the Broad Top coals are those of the lower coal-system, small beds and subdivided, hence coming to market in a soft and dirty condition.

The Salisbury upper (Pittsburgh) coals, if coked, can go down to Pittsburgh in competition with the Connellsville upper (Pittsburgh) coal, coked; but the Connellsville coal, raw, is too bituminous to come eastward to Baltimore and Philadelphia in competition with the Salisbury and Cumberland coals, raw. These, then, compete with each other, but without competition from any other quarter whatever, forming virtually two competing but allied monopolies of the best steam-coal known.

To feel the full force of this remark it must be kept in mind that what is called *par excellence* "Cumberland coal" comes from the "Big bed," (George's Creek bed, Pittsburgh bed,) in the center of the Cumberland Basin, and what will soon be equally famous as "Salisbury coal" will come from the same Big bed, Pittsburgh bed, in the central ridge of the First Somerset or Salisbury Basin.

In considering the commercial value of these coal-beds in comparison with each other and the transportation distances by the many existing and proposed new routes to the eastern markets, it is to be borne in mind that the two coals, the Salisbury and Cumberland, come from one and the same (Pittsburgh, Connellsville, Salisbury, George's Creek) upper coal series Great coal-basin, and are of equal purity, and the beds of equal size or rather of greater size at Salisbury.

It is especially to be remembered that the Irwin coal (Westmoreland) is only to be used for gas-making purposes, and can only be brought eastward for those purposes; for coking purposes it must go to Pittsburgh and down the Ohio. Whereas the Salisbury coal will rival the Cumberland coal on a footing of equality, as the best steam-coal known, and have nothing but the Cumberland coal to compete with; for the Broad Top and Alleghany Mountain steam-coals all come from the smaller, more slaty, and softer beds of the lower coal system, and therefore always must be of inferior value in the market to the Cumberland and Salisbury coals; while on the other hand the Salisbury coal will coke admirably also, and command an equal standing in the Pittsburgh and down-Ohio-River markets.

Observing, finally, that the noble coals of Jefferson and West Clearfield, about to enter the seaboard markets, on the completion of the Low Grade Railroad, must travel three hundred and twenty miles to reach Philadelphia, and then come into the sea-

board market in competition with the Irwin gas-coal kinds, (transported three hundred and thirty-two miles,) to which they really belong, (although the beds are the upper beds of the lower coal system,) and cannot, therefore, compete well with steam-coals.

Considering all these points, I think I have justified the very exceptionable value which I have for many years past attached to the Salisbury coal-basin.

NOTE.—Analysis referred to:

Analysis of the five-foot Salisbury bed, mentioned in this report, made by Booth & Garrett

Gas.....	16.02	} Volatile matter	25.75
Tarry matter and water.....	9.73		
Fixed carbon.....	68.40	} Coke	74.25
Ash.....	5.85		
			100.00

NOTE.—Assuming the specific gravity of the gas to be 0.45 compared with air as unity, the amount of gas yielded by one pound of coal will be 4.64 cubic feet. This analysis shows, first, the resemblance of this coal to the Cumberland; second, the great amount of coke it will produce even after a certain loss of fixed carbon.

Appendix C.

LETTER OF MR. B. H. LATROBE.

BALTIMORE, March 2, 1874.

DEAR SIR: Upon my return home yesterday I received your letter of the 26th February, asking for information in regard to the cost of the Sand-Patch tunnel upon the line of the Pittsburgh and Connellsville Railroad.

The work on this tunnel, of 4,800 feet in length, was commenced and carried on for a couple of years or more prior to my connection with the road, and I am not now able to say from sources within my reach what it cost during that time. It was resumed in 1865, after a suspension of about eight years, and within the next two years the sum of \$31,549 was expended in removing 7,620 cubic yards, at an average cost of \$4.14 per cubic yard. This work was done by the day under the superintendence of an agent of the company, an experienced and trustworthy person, formerly and since a contractor upon the line. It gives, therefore, a pretty good criterion of actual cost without profit, although if done by contract the net cost might have been somewhat less, the desire to make a profit affording, even to an honest man, an additional incentive to economy.

There were 350 feet linear of heading and 500 feet of bottoming in the 7,620 cubic yards, the former constituting about one-third and the latter two-thirds of the whole sectional area of the tunnel, which was 16 feet wide by 18½ feet high, with semicircular roof where masonry was not required, with 2 to 3 feet additional width and height where lining was needed. The lining was of stone, as no good brick-clay was found in the neighborhood, and very good sandstone abounded in the large boulders of the conglomerate rocks which were found strewn over the surface in the vicinity.

The employment of this stone permitted the arch to be reduced from 18 inches (had it been of brick) to 12 inches in thickness, which sufficed for so moderate a span, the space over the arch not requiring more than 2 or 3 feet of packing, except at certain points where the rock had fallen more from overhead. The strata were inclined crosswise to the line of the tunnel, the dip being 40° or 50°, and the strike being nearly parallel to the axis of the tunnel, the grade ascending 1 in 100 from east to west, and the rock consisting of the old red sandstone underlying the coal-measures. A long canal-tunnel would cut across the stratification and encounter the lower coal-measures after passing through the old red and the mountain limestone and the millstone grit. After the final resumption of the work on the Sand-Patch tunnel in 1868, it was let to contractors, at the following prices:

Heading, what remained, (748 cubic yards,) nearly all being removed under previous contract	\$7 per cubic yard.
Bottoming, what remained, (27,725 cubic yards).....	\$2.95 per cubic yard.
Stone packing over arch, (5,085 cubic yards).....	\$2.25 per cubic yard.
Side walls, stone masonry, (374 perches of 25 cubic feet)	\$12.00
Arch, stone masonry, (1,899 perches of 25 cubic feet).....	13.25

The railroad company furnished cement and sand, costing about \$1 per perch, to be added to these prices.

The tunnel and approach-cuts, which were long, were made passable by trains in March, 1871; and since, some extension of the arching has been made, so that now about half the whole length, I think, is lined.

Since writing the above I have found some papers which give the prices of the first contract, made in 1853, viz: Heading, \$5.25; bottom, \$2; packing over arch, \$2; shafts, (four in number, and 88, 120, 142, and 178 feet deep, respectively,) \$6 per cubic yard. These were sunk before I took charge of the work. The first contractors abandoned the work, the prices being inadequate even at that day of lower prices of everything. The last contractors made a small profit by close management. The whole tunnel and approaches have cost about \$420,000.

I should think it very unsafe to assume the preceding prices in estimating the cost of a long canal-tunnel, which might readily be 100 per cent. higher, and, for the shafts, three or four times as high.

The Sand-Patch tunnel was remarkably free from trouble with water, the rock of alternately hard and soft ledges, unfit for masonry, and much of it decomposing when exposed to the atmosphere.

I am, dear sir, respectfully yours,

BENJ. H. LATROBE.

Col. W. E. MERRILL,
United States Engineer Office, Cincinnati, Ohio.

INCLINED PLANES.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, May 8, 1874.

GENERAL: In my report on the extension of the Chesapeake and Ohio Canal, dated March 20, 1874, and printed as Executive Document No. 208, House of Representatives, Forty-third Congress, first session, I stated, under the heading "Inclined Planes," that Colonel Sedgwick was preparing a special paper on the method of canal navigation by the use of inclined planes, which I intended to forward with the request that it might subsequently be attached to my report. I have just received the paper in question, and I herewith forward it, with the request that it may also be transmitted to Congress for publication. The subject discussed is one whose details are not widely known, and the information which the report contains will be quite useful to all engineers who have to discuss the problem of canal navigation in mountainous districts.

Respectfully, your obedient servant,

WM. E. MERRILL,
Major Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers.

Supplemental report of Mr. Thomas S. Sedgwick, Assistant Engineer.

WASHINGTON, D. C., March 30, 1874.

COLONEL: In relation to the extension of the Chesapeake and Ohio Canal from Cumberland, Md., to Pittsburg, on the Ohio, I have the honor to make a supplemental report on the study of "inclined planes" as a means of raising and lowering boats from one level of a canal to another, instead of the canal lift-locks.

The use of such planes is not new, although they are somewhat of a novelty. They have been in use on the Duke of Bridgewater's Canal in England, and planes carrying caissons full of water in which the boats were floated have been used on the Monkland Canal, near Glasgow, Scotland; but the most noted and, doubtless, the most successful application and use of inclined planes is a matter of national pride to the United States, in the example of their efficiency and economy in cost, and saving of time in transportation, as used on the line of the Morris Canal, in New Jersey.

The Morris Canal extends across the northern portion of New Jersey, from Easton, Pa., on the Delaware River, to tide-water at Newark, on the Bay of Newark, a distance of one hundred and one miles. The total rise and fall on the canal is stated at 1,557 feet, of which 223 feet is overcome by locks of various lifts, and 1,334 feet by inclined planes,

averaging 58 feet lift each, of which one, near the western terminus of the canal, has a height of 100 feet.

These planes were, when first constructed, operated in connection with an ordinary lift-lock placed at the head of the plane, connected with the upper level or pool, into the bottom of which lock the track (an ordinary railway-track) of the plane was laid, and led down the plane to the lower pool. The boats were carried up or down the plane on a wheeled carriage running on a railway-track operated by an endless chain passing around large horizontal pulleys, (fixed at the head and foot of the plane,) and attached to a large winding drum operated by a turbine motor, and the usual gearing and machinery for transmitting such power. The turbine with its machinery is located in a house on one side of the plane at about the middle of its length, and is operated by the head of water taken from the upper pool. The boats were taken into the locks at the head of the planes in the usual manner, and as the prism of lift-water was discharged the boat settled down into the carriage and was let down the plane to the lower pool, where the boat, following the inclined plane to a depth greater than the draught of the boat, floated and was detached, passing on its way. Boats moving in the contrary direction were drawn over the carriages as they stood in the lower pools at the foot of the planes and made fast thereto, and the machinery being put in motion, the carriage rising along the planes, the boats settled down upon them and were carried up to the head of the planes and into the locks, which were then closed, the prism of lift-water let in, and the boats were raised to the upper pool and passed on their way.

The locks at the heads of the planes have been taken away, and the railways of the planes are carried over into and down to the bottom of the upper pools, where the boats are received and discharged from the carriages in the same manner as at the foot of the planes in the lower pools. This arrangement of the two planes is called a "summit-plane," and this is the kind of plane I have considered in connection with the extension of the Chesapeake and Ohio Canal, with special reference to their application on the mountain section of the Savage River route, between the mouth of Savage River and Salisbury, on the Castleman River, and at one or two places farther west on the route where their usefulness is apparent.

The loaded boats of the Morris Canal, together with the carriage, weigh about 110 tons. Observations made on the operating of a plane at Newark, rising one foot in ten, and having a lift of 70 feet, showed that boats were readily and efficiently passed from one pool to the other, over a horizontal distance of about 1,000 feet, in four minutes, equal to a rate of twenty-eight miles per hour.

DESCRIPTION AND ESTIMATE OF COST.

The accompanying drawings, showing a profile and plan of a single-track plane, and a plan of a double-track plane, illustrate the arrangements and dimensions of a summit-plane of 64 feet lift, rising one foot in 10 feet. H is the upper and L the lower pool or level of the canal, connected by the inclined plane. The summit of the plane at S is from 1½ to 2 feet higher than the surface of the upper pool, and the second branch of the plane descends to the bottom of the upper pool at the rate of 1 foot in 10 feet and the foot of each plane is continued beyond the ordinary depth of the canal to gain depth enough to allow the carriage to pass under the boat as it floats, as shown at A. The additional depth shown in this plan is about 6 feet, requiring a total depth of 12 feet. P and P are the horizontal pulleys around which the traction cable passes connecting the carriage with the winding-drum D. They are *firmly* fixed to masses of masonry. The turbine motor, connecting with the winding drum by suitable gearing, is placed in a suitable house at the foot of the plane to utilize the available hydraulic head between the pools.

The carriage is formed of two parallel trusses, each resting on two trucks of two iron wheels, each flanged like ordinary railroad-car wheels. The trusses are connected by bearing joists or floor-beams on which the boats rest while being moved up or down the plane. The trusses are carried by bolsters resting on axle-pivots at O O in such manner that the trucks may, in moving over the crest of the plane, adjust themselves to the plane of the track by turning about the axle-pivots. The track upon which the carriage runs consists of the ordinary T railroad rail laid on longitudinal stringers, which are placed on a foundation wall of masonry, put deep enough in the ground to be undisturbed by the freezing of the ground in winter. The traction cable C is supported on grooved carrying-wheels placed at proper intervals, and iron rollers are used to carry the cable over the crest of the plane. The carrying-wheels placed between the drum and the horizontal pulleys move horizontally on their axles, adapting themselves to the horizontal motion of that portion of the cable as it winds off or on the drum. The planes are increased in length in proportion to the depth reached in each pool, and a portion of level track is laid in each pool for the carriage to rest on when receiving or discharging a boat, the pulleys being placed at the ends of the level portion of track.

The total height of the main plane from the bottom of the lower pool to its crest or summit is 77.5 feet, and the height of the plane in the upper pool is 13.5 feet. The horizontal lengths of the planes are therefore 775 feet and 135 feet, and their slope lengths are 778.86 and 135.67 feet, which, together with two level portions of 100 feet each, makes the track needed 1,114.5 feet long. [Fifteen feet are taken from each end, leaving 1,085 feet of track.]

The length of cable used is twice the lengths between the pulleys, measured on the planes, the circumference of one pulley, and the distance passed over by the carriage in going from one pool to the other, say 980 feet, a total length of 3,235 feet. The ends of the cable are separately fixed to the drum, and a length of cable equal to the distance passed over by the carriage is always wound on the drum. In the double-track plane the length of cable is twice the distance between the pulleys by the planes, once and a half the circumference of a pulley, the distance between the tracks, the distance passed over by the carriage, and twice the distance from the drum to the pulleys in the upper pool, in all 4,140 feet.

The gauge of the track is 18 feet, and the slopes of the canal-prism, if carried to a depth of 12 feet, will not provide room enough for the single-track plane, and the necessary widening and the excavation of the prism between the foot of each plane, and the surface of the pool is considered in the cost of the single-track plane; and in the cost of the double-track plane the expense of widening to a width of 75 feet for a distance of 300 feet in each pool is included.

The expense of deepening the canal to a depth of 12 feet for a distance of 100 feet in each pool is also included in the cost of the single-track plane.

COST OF SINGLE-TRACK PLANE.

Deepening pools, 2,150 cubic yards, at 40 cents.....	\$360 00
Grading surface of plane, say 3,000 cubic yards, at 30 cents.....	900 00
Trenches for masonry of track, 500 cubic yards, at 30 cents.....	150 00
Foundation walls, 350 cubic yards, at \$8 per yard.....	2,800 00
Track-stringers, 15,000 feet, board-measure, at \$35 per thousand.....	525 00
Fastening stringers to wall, 450 pounds bolts, at 6 cents.....	27 00
Track-rails, 80 pounds per yard, 25.8 tons, at \$90 per ton.....	2,322 00
Joint splices, 70, at \$1 each.....	70 00
Track-spikes, 400 pounds, at 5 cents.....	20 00
Laying track, say.....	100 00
Carrying-wheels and rollers, 8,500 pounds, at 5 cents.....	425 00
Grooved-pulleys, 5,000 pounds, at 4½ cents.....	225 00
Traction-cable, 3,235 feet steel-wire cable, 2½ diameter, \$1.65.....	5,337 75
Turbine diameter, (in place).....	1,000 00
Gearing 20 tons cast iron, at \$100 per ton.....	2,000 00
Drum and fixtures, 2 tons, at \$100 per ton.....	200 00
Flume and penstock, complete, with feed-gate.....	5,640 00
Fixing grooved pulley, (masonry and iron).....	450 00
House for machinery.....	1,500 00
Boat-carriage, carefully figured.....	2,500 00
Sum of items.....	27,051 75
Contingencies, 10 per cent.....	2,705 17
Cost of plane.....	29,756 92

COST OF DOUBLE-TRACK PLANE.

Cost of single-track plane.....	\$27,052 00
To which add the following quantities:	
Additional widening, 3,000 cubic yards, at 40 cents.....	1,200 00
Trenches for foundation, 500 cubic yards, at 30 cents.....	150 00
Foundations, track-masonry, 350 cubic yards, at \$8.....	2,800 00
Track-stringers, 1,500 feet, board-measure, at \$35 per thousand.....	525 00
Stringer-fastenings, 450 pounds bolts, at 6 cents.....	27 00
Track-rails, 25.8 tons, at \$90.....	2,322 00
Joint splices, 70, at \$1.....	70 00
Track-spikes, 400 pounds, at 5 cents.....	20 00
Laying track.....	100 00
Grooved pulley, (large,) 5 tons, at \$100 per ton.....	500 00
Carrying wheels and rollers, 8,500, at 4½ cents.....	225 00
Traction-cable, 910 feet, at \$1.65.....	1,501 50
Fixing pulley.....	250 00

Boat-carriage, as figured	\$2,500 00
Movable carrying-wheels, 2,500 pounds, at 6 cents	150 00
Sum of items	39,392 50
Contingencies, 10 per cent.	3,939 25
Cost of double-track plane.....	43,331 75

ECONOMY OF COST AS SUBSTITUTE FOR LOCKS.

In a mountainous country, where a considerable elevation is to be overcome in comparatively short distances, and where the ordinary lift-locks must be placed in flights, so called, that is, adjacent to each other, or be placed so close together as to seriously retard navigation as to time, the pools being so short that the average usual speed cannot be acquired between the locks, (and the time lost in locking and attendant delays consume a great part of the time on the section where the locks are so close together,) or where, to avoid such loss of time, the lifts of the locks must be made so great that the requisite supply of feed-water cannot be had, (such locks being also very expensive in their construction,) the locks in either case being a principal item of the cost of the canal, as well as a continual source of delay in transportation, if there should be but one lock for each mile, the cost of locks would be but some \$16,000 per mile; but if the levels of the canal, as in some well-known cases, were ten or twelve miles long, then the cost of the locks would be but some \$1,500, or even only \$1,000 per mile for the ordinary lifts of eight feet; on the contrary, if the canal is to be carried into a mountainous region, where the slope of the valleys must be followed at a rate of 50 or 60 feet rise per mile, requiring 6 or 8 locks per mile, their cost becomes the principal item of expense, and may reach as much as \$130,000 per mile.

Considering the section of the Chesapeake and Ohio Canal between Cumberland and Connellsville, via the Savage River route, as presented in my report of January 30, 1874, we find the cost of locks between Cumberland and the mouth of Savage River equal to 28 per cent. of the whole cost of the canal—\$21,000 per mile—the locks occurring at intervals of three-quarters of a mile. At the mouth of Savage River the ascent of the mountain begins, and between that point and the summit, a distance of sixteen miles, there are 140 locks, aggregating more than 75 per cent. of the estimated cost of the canal for that section.

If to avoid this high ratio of cost of lift-locks on the line of canal, we consider the substitution therefor of the single-track inclined-plane, as described above, we find that one plane overcomes the lift of eight locks of 8 feet each. [This lift of the plane was assumed with special regard to this section of the canal, as, in my judgment, they can be economically placed at average intervals of about one mile.] Eighteen planes would be required to overcome the elevation of the Savage River section, where there are 140 locks, and two planes for the section between the western end of the Summit Tunnel and the mouth of Piney Run, where there are 16 locks in 6 miles. On these two sections the slopes of the hill-sides are favorably conditioned for supporting the levels of the canal for such use of the planes.

The 156 locks, estimated on this section of the canal at \$16,500, (with 10 per cent. contingencies,) would cost \$2,574,000, while, on the contrary, the 20 planes would cost but \$595,138.40, a difference of \$1,978,861.60 in favor of the planes, equal to a saving of 76.88 per cent. of the cost of the locks, and reducing the cost of this section of the canal by 58.58 per cent. Comparing the cost of the plane with the cost of the eight locks it would take the place of, there is a difference of \$102,243.08 in favor of the cost of the plane, overcoming the same height of lift by the plane as by the eight locks, at 22.5 per cent. of the cost of the locks.

There are no natural indications that planes could be used between Cumberland and the mouth of Savage River, and the cost of supporting the levels of the canal on the hill-sides might be a greater increase (in the cost of high embankments, or the crossings of lateral ravines or valleys, and high aqueducts) than would be saved by the planes of less lift than described above.

There are, however, two places on the line of the canal west of Meyer's Dale City where planes could be advantageously used. Referring to the report of the Board of Internal Improvement, (1st subdivision, western section,) there is a reference to the Ohio Pyle Falls, where the fall is 96 feet in the distance of one mile. The cost of a plane of this height would be, in addition to the cost of the 64 feet high plane, the cost of 321.6 of track and traction-cable and their accessories, amounting to \$3,068.45, including 10 per cent. contingencies, making the total cost of the plane \$32,825.45; while, on the other hand, twelve locks of 8 feet lift each would cost \$198,000, a difference of \$165,174.55 in favor of the plane. The other place I refer to as indicating the substitution of a plane for locks is at the mouth of Castleman River. The use of a plane at this point would save \$102,243, as found above. These items of difference in

cost aggregate \$2,246,279.15, which is applicable to the reduction of the cost of the canal as estimated in my former report, reducing the cost from \$19,937,285 to \$17,691,006, a reduction of 11.25 per cent.; a sum that, rated as an invested capital, at 6 per cent. per annum, is equal to a saving of \$134,776.75 in annual expense of maintaining the canal.

This character of inclined plane could also be applied on the Wills Creek section of the Wills Creek route under very similar conditions, as will be seen by reference to the report of the Board of Internal Improvements, "eastern portion" of middle division, where the intervals between the locks are given as 180 yards, equal to 540 feet, and the average of six locks per mile obtains between Cumberland and the summit of the mountain.

EXPENDITURE OF WATER IN OPERATING THE TURBINE MOTORS.

In determining the work to be done in moving boats over the plane, the weight of the boat is taken at 30 tons, the weight of the cargo at 120 tons, and the carriage at 35 tons, making an aggregate load of 185 tons, or 414,400 pounds. Resolving this weight with reference to the plane rising 1 on 10, we have for the pressure perpendicular to the plane 412,343.4 pounds, and for the weight acting downward, parallel to the plane, 41,234.34 pounds. This weight, together with the friction of the load, is to be overcome in moving the load up the plane. Taking the friction at eight pounds per ton of the weight normal to the plane, we have for the rolling friction 1,472.66 pounds, which gives the force to be applied in moving the load 42,707 pounds—moment pounds—parallel to the plane.

To raise the load one foot high, the travel along the plane will be 10.05 feet; and the corresponding foot-pounds will be 429,205.35. To move the boat at a rate of $2\frac{1}{2}$ miles per hour gives a rate of 3.66 feet per second horizontal, or 3.685 feet along the plane, and the corresponding foot-pounds are 157,375.44 pounds. As 550 foot-pounds are rated as one horse-power, we require 286.20 horse-power to move the load 3.685 feet in one second, or to raise it one foot high in one second. Adding five per cent. for friction of machinery, we get quite nearly 300 horse-power as the measure of work per second required for the turbine motor.

To determine the diameter of the turbine to do this work, and the quantity of water expended per second, in cubic feet, with a height of head of 64 feet, we have, by the formulas and proportions deduced from the Lowell hydraulic experiments, (by Mr. James B. Francis, C. E.,) for the diameter of the turbine 3.71 feet, and the water discharge 56.26 cubic feet per second. To move the carriage over the distance from the average place at the foot of the main plane until the rear wheels are over the crest of the planes toward the upper pool, whence the force of gravity will take it to the foot of that plane, a distance of 825 feet, will require 3.75 minutes' time and expend 12,433 cubic feet of water. [These formulas consider the useful effect of the turbine as 0.75 of that due to the hydraulic head.]

As turbines are so arranged that the expenditure of water is in proportion to the work done, we have an expenditure of 4,368 cubic feet of water to draw an empty boat, 65 tons, (with carriage,) up the plane, and, to move the same loads from the upper pool over the crest of the plane a distance of 200 feet, we have an expenditure of 3,014 cubic feet for a loaded boat, and 1,059 cubic feet for the empty boat. These quantities need not be necessarily fully expended, as a part of the work is done in moving the load over whatever distance the rear trucks of the carriage may be from the foot of the plane when the movement begins, and in carrying the rear trucks of the carriage over the crest of the plane; times, in which the full power of the turbine is not required.

The movement of boats up or down the slopes of a canal, whether operated by planes or by locks, are somewhat analogous. When the canal is operated by locks, each loaded boat passing up the canal draws from the upper pool one lockful of water, plus the boat's displacement, and an empty boat one lockful, plus its displacement; and in passing down the canal each boat draws off from the upper pool a lockful of water less its displacement, when the locks are found empty; but if the locks are found full, the down-going boats will force the quantity of their displacement out of the locks into the upper pool. [A lockful of water is considered as part of the lower pool.] In the case of the locks under consideration, the prism of lift contains 12,000 cubic feet, and a loaded boat displaces its weight of 150 tons, 5,391 cubic feet, and an empty boat its weight of 30 tons, 1,078 cubic feet, of water; and in making a comparison of the expenditure of water in the two systems of working the canal, the displacement of the downward-going boats will be credited for the case of finding full locks.

To make the conditions of comparison equitable in the two systems, we will first consider the expenditure of water by four boats (two loaded and two empty) going up, and two loaded and two empty going down, giving the benefit of full locks to one loaded and one empty boat going down

Direction and condition of boats.	Lock system.	Plane system.	Difference in favor of plane.
	<i>Cubic feet.</i>	<i>Cubic feet.</i>	<i>Cubic feet.</i>
Two loaded boats going up	34, 782	24, 866	9, 916
Two empty boats going up	26, 156	8, 736	17, 420
Loaded boat down, (lock empty)	6, 609	3, 014	3, 595
Empty boat down, (lock empty)	10, 922	1, 059	9, 863
Loaded boat down, (lock full)	5, 391	3, 014	2, 377
Empty boat down, (lock full)	1, 078	1, 059	19
Total for eight boats	72, 000	41, 748	.....
Giving an average for each boat	9, 000	5, 218½	3, 781½

Showing a difference of 42 per cent. in favor of the inclined-plane system.

If, for a second comparison, we consider only loaded boats going in each direction, taking for example two boats each way, and giving one boat the benefit of finding a full lock going down, we find as follows:

Direction and condition of boats.	Lock expends.	Plane expends.	In favor of plane.
	<i>Cubic feet.</i>	<i>Cubic feet.</i>	<i>Cubic feet.</i>
Two loaded boats going up	34, 782	24, 866	9, 916
One loaded boat down, (lock empty)	6, 609	3, 014	3, 595
One loaded boat down, (lock full)	5, 391	3, 014	2, 377
Totals for four boats	36, 000	30, 894	.....
Giving an average for each boat	9, 000	7, 724	1, 276

Showing a difference of 14 per cent. in favor of the inclined-plane system.

If we apply this method of comparison of the expenditure of water to the summit-level of the canal, we shall find that, when we consider the system of inclined planes, each loaded boat passing the summit draws off from the summit-level 15,447 cubic feet of water, and each empty boat 5,427 cubic feet of water, in the operation of the two summit-level planes, an average of 10,437 cubic feet to each boat; and if we take the case of the locks, each boat passing the summit, loaded or empty, draws off either 24,000 cubic feet or 12,000 cubic feet, as the lock by which the boat leaves the summit-level is found empty or full, an average of 18,000 cubic feet for each boat, a saving in the expenditure of water of 42 per cent. in favor of inclined planes. If we consider only loaded boats passing the summit we find for the inclined-plane system an expenditure of 15,447 cubic feet of water for each boat, and for the lock-system an average (again) of 18,000 cubic feet, or 14 per cent. in favor of the inclined plane. This is the best *practical* comparison that can be made in favor of the lock-system, and shows that the expenditure of water by this system of inclined planes is 86 per cent. of the expenditure by locks.

The most favorable assumption that can be made in favor of locks is that which presumes that the boats alternate in direction regularly and continuously day by day, and month by month, throughout the season, in which case each boat would expend but one lockful of water in passing the summit-level; but this recurrence of boats is not presumable, and any derangement of this order for one day is not compensated by a similar disorder of recurrence on following days, and consequently presuming that two boats may go in one direction to one boat in the contrary direction, one and one-half lockfuls of water are estimated to be expended by each boat passing the summit-level. This irregularity of directions of boats increases the expenditure of water at the summit by 50 per cent. in the lock-system, but with the system of inclined planes such irregularity in direction makes no change in the quantity of water expended at the summit, thus avoiding any doubt as to the supply required for a given number of boats, as each boat requires a given expenditure in passing the summit-level. In the case of locks, if twenty or thirty boats should pass the summit in the same direction and following each other they would each expend two lockfuls of water, or more than double the quantity that would be expended by the same number of boats passing in the same order by the system of planes.

There is, however, a general condition of commercial transportation, which considered as a basis of comparison between these systems of operating the canal with especial regard to the expenditure of water in its daily operations, gives great weight to the system of inclined planes.

The movement of freights between the East and the West, by the lines of transportation already established, shows that the freights eastward are greatly in excess of the freights westward, in the proportion of about 6 to 1. This indicates that about six loaded boats would go eastward to one loaded westward, that five-sixths of the boats going westward would be empty, and all going eastward would be loaded, consequently we may presume that of twelve boats passing the summit-level of the canal seven may be considered as loaded and five may be considered as empty. By the system of locks each boat passing the summit-level will have an average expenditure of 12,000 cubic feet of water, or 216,000 cubic feet for the twelve boats, but by the system of inclined planes the seven loaded boats will expend 108,129 cubic feet and the five empty boats will expend 27,125 cubic feet of water, a total of 135,254 cubic feet, an average of 11,271 cubic feet for each boat, or only 62 per cent. of the expenditure by locks. Upon this hypothesis of the movement of boats loaded and empty, the quantity of water required for operating the inclined planes may be determined definitely for any given number of boats, and generally the quantity of supply of feed-water at the summit may be determined upon the basis of tonnage per annum; 100 boats would carry (58 being loaded and 42 empty) 6,960 tons, and expend 1,127,117 cubic feet of water, about 162 cubic feet per ton, varying as the tonnage; whereas, on the contrary, by the lock-system the 100 boats passing the summit would expend equal quantities of water whether loaded or empty.

It may be further remarked that by the system of planes the loss by leakage at the locks would be entirely obviated at the summit-level, an insignificant quantity probably, but yet worthy of being noted.

Referring again to the comparison of quantities of water expended at planes and at locks in the eastern slope of the canal, and applying the hypothesis of non-balance of freights eastward and westward, we find that six loaded boats passing eastward, and one loaded and five empty ones passing westward, will expend 52,357 cubic feet of water, and by the same movement of boats through a lock by the favorable condition of three eastward boats, finding full locks, there will be expended 73,357 cubic feet of water, nearly one-half more than the quantity expended by the inclined plane. This feature of the comparison, together with the absence of leakage at the summit-locks, shows that, in the system of inclined planes, the storage water in the summit-level is under better control in the matter of its distribution down the slope of the canal, saving in the last case 33 per cent. of the water expended by the system of locks, under the same condition of tonnage. This feature gives great weight to the system of inclined planes.

The local conditions in regard to these comparisons are, on the Savage River section of the canal, especially favorable to the system of inclined planes.

EFFECT ON THE TONNAGE CAPACITY OF THE CANAL.

It was shown in my former report that the tonnage capacity of the canal is dependent on the facility for passing boats at the restricted points as at the locks, and was equal, under ordinary circumstances, to about eight boats per hour, and 192 per day. Upon the basis of movements of freights eastward and westward, given above, seven-twelfths of these—12 boats—are loaded, aggregating a tonnage of 4,032,000 tonnage for a season of 300 days. In the case of the inclined planes, boats can be passed up (and down) over a distance of 950 feet in 4.4 minutes, allowing for time to get into the carriage, say ten boats per hour, increasing the capacity 25 per cent. With regard to the convenience of passing boats at a plane, it may be readily shown that they can be passed over the plane in one-half of the time, or in any other ratio, by the same expenditure of water, by increasing the power of the turbine motor.

If double-track planes were applied to the canal at the increased cost of 50 per cent., the capacity is to some extent unlimited, and ten boats could be passed in each direction in each hour, doubling the capacity last stated, which would give 480 boats per day, and 144,000 boats, 17,280,000 tons, per annum of a season of 300 days.

ECONOMY OF TIME IN TRANSPORTATION.

To determine the time of transit over a canal operated by locks, the time taken up in slowing up the boat to enter the lock, and the time taken up in getting under way again at the usual speed, must be taken into the account as the means of determining the time lost by retardation of speed, as well as the time required in locking through. A like amount of retardation takes place in passing a plane, as the boat must come very nearly to a dead stop in entering the carriage, but by good management the boat may be made to leave the carriage with the communicated velocity acquired in passing over the plane—2½ miles per hour.

[This is the practice on the Morris Canal.]

To determine the time consumed at locks in retardation and locking, we may take the operations on the completed canal as a basis. Under the most favorable conditions of the lock being open to an approaching boat, the tow-line is cast off at the distance of 350 feet from the lock, and the boat comes to a stop when in the lock, and we will assume that an equal distance is required to get under way again at the usual speed.

The lock for this purpose is taken to be 120 feet long; and the distance occupied in slowing up, locking, and getting under way again is therefore 820 feet at each lock. The usual speed acquired over the canal between locks is two miles per hour, rarely faster. Loaded boats make the trip from Cumberland to Georgetown, a distance of 184.5 miles, in $4\frac{1}{2}$ days, passing through 74 locks, making an average speed of 1.7 miles per hour.

The total distances taken to slow up, lock, and get under way are, for 74 locks, 60,680 feet, leaving 913,480 feet, over which the speed of two miles per hour is made, requiring $86\frac{1}{2}$ hours of time, and the time remaining of $4\frac{1}{2}$ days, $21\frac{1}{2}$ hours, is taken up at the locks in retardation and locking, equal to $17\frac{1}{2}$ minutes at each lock, in passing over 820 feet of distance. To render this case somewhat more favorable, we will assume that but 15 minutes' time are taken up in slowing up, locking, and getting under way.

In applying these measures of time to the portion of the canal between Cumberland and Connellsville, via the Savage River route, we will consider it in characteristic section. Connellsville to mouth of Piney Run, 68 miles, with 134 locks; Piney Run to mouth of Savage River, twenty-eight miles, with 156 locks; and Savage River to Cumberland, thirty-one miles, with 42 locks.

In passing over the first section of 68 miles, a boat will take up 33.5 hours in passing 134 locks and 109,880 feet, leaving 249,160 feet to be passed over at the rate of two miles per hour, requiring 23.6 hours, a total of 57.1 hours for this section. On the middle section, deducting the tunnel summit-level of 5 miles length, which will be passed in 2.5 hours, 39 hours will be taken to pass 156 locks and 127,920 feet of distance, equal to 24.23 miles, 1.23 miles more than the distance to be passed over on this section, exclusive of the tunnel. The reason for this result is that the distances between the locks average about 660 feet, 40 feet less than is assumed to be taken up in getting under way, and slowing up to enter the next lock, and the boat does not get the speed of two miles per hour, as assumed, but in the half distance between locks will acquire a speed of 1.89 miles per hour. [As we have assumed nearly $2\frac{1}{2}$ minutes less time at locks than was found by the basis of times on the portion of canal in operation, we may disregard this saving of a fraction of a minute.] The whole time on this section is 41.5 hours. The time occupied in passing over the section from the mouth of Savage River to Cumberland, we have 10.5 hours to 42 locks, and 34,440 feet of distance and 12.24 hours to pass over the remaining 129,240 feet or 24.48 miles, making for this section 22.74 hours, and for the whole distance between Cumberland and Connellsville, 121.34 hours, a rate of 1.05 miles per hour. If the 17.4 minutes found to be occupied at each lock had been used in these calculations the time would have been found to have been 13.28 hours more, or 134.62 hours.

BY SYSTEM OF INCLINED PLANES.

The time required for the passage of boats along the canal where inclined planes are used is to be determined in the same manner as for the system of locks. Equal times and distances are taken up in slowing up to enter the carriage, as in the case of locks, but no time is lost in retardation in getting under way again. If a boat, moving at the rate of two miles per hour, comes to a stop in 350 feet when the propelling power is stopped, the average rate of speed has been one mile per hour for the 350 feet of distance and the time 4 minutes, quite nearly. In the calculations for determining the expenditure of water in passing the plane, the rate of two and one-half miles per hour was assumed, and to pass from the upper to the lower pool, or *vice versa*, a distance of, say, 990 feet, the time will be $4\frac{1}{2}$ minutes, making $8\frac{1}{2}$ minutes for the time taken at each plane to pass over a distance of 1,340 feet.

Considering first the section between the mouth of Piney Run and the mouth of Savage River, a distance of twenty-eight miles, with 20 planes, we have for the time occupied at planes, 2.83 hours and 26,800 feet of distance, and the remaining distance 22.92 miles is passed over in 11.46 hours, and the section is passed in 14.3 hours, (a saving in time of 27.2 hours on this section,) with a rate of two miles per hour, quite nearly, the section being passed as if it were *one continuous unobstructed level*.

The saving of time at the other points named would be, at the mouth of Castleman River, difference between 2 hours occupied at the eight locks in going over 6,520 feet and $8\frac{1}{2}$ minutes and 29.4 minutes (37.9 minutes) to pass the same distance by the plane, a saving of 1.37 hours.

At the Ohio Pyle Falls, a plane of 96 feet lift would give a distance of 1,310 feet to be passed in 6 minutes, and 1,660 feet in 10 minutes; 12 locks would require 3 hours of time to 9,840 feet of distance, while in passing this distance with the plane but $56\frac{1}{2}$ minutes would be taken, saving here 2.06 hours; and the whole time that would be saved between Connellsville and Cumberland is 30 hours and 38 minutes, (equal to a shortening of the canal by 61.26 miles,) making the time from Connellsville to Cumberland 94 hours, only four days, and the average speed 1.35 miles per hour. If the time of passing locks as found by the operations of the canal in use, had been used, the saving in time would have been almost $4\frac{1}{2}$ days.

It is quite probable that planes could be introduced at other places on the canal, but the surveys are not made in such detail as to determine this.

From the above discussion of planes and locks it is apparent that if planes of higher lift could be used, the economy of time and cost would be greater yet; and that were the canal operated to its full capacity with planes, the planes could be double-tracked at an increased cost not exceeding 46 per cent. of the cost of the single-track planes, which would establish a double line of boats moving in opposite directions as fast as two miles per hour over the mountain section; nor would the double-track planes expend as much water in operating the turbines as would the single-track planes, because the load to be moved up or down the plane would be counterbalanced by 35 tons, or 60 tons, or 185 tons; and in all cases 33 per cent. of a saving in work would take place; and in the case of the movement of two boats at the same time, one or the other of the boats might be said to have been moved without any expenditure of water; and for the case of six loaded boats down, or eastward, and one loaded boat and five empty ones westward, on the Savage River section, if the boats could be moved over the planes in pairs, the expenditure of water would be for the five empty boats up, and the one loaded one, 36,204 cubic feet, or an average of 2,901 cubic feet for each boat as compared with 4,363 cubic feet for each boat as found for the single-track plane, a saving, again, of nearly one-half of the quantity estimated for the operation of single-track planes.

In the operations of the double-track plane, when two boats were to be moved at the same time, double work would have to be done in moving the boats over the length of the upper plane, and for this purpose a turbine of double the power figured for the single-track plane would be required with double the expenditure of water for that time, and this double expenditure is considered in the calculation of the last average quantity of 2,901 cubic feet. Fixed caissons carrying water in which the boats may be floated while passing over the plane, have been used, as noted in the beginning of this report. Such an arrangement would add the weight of caisson to the load to be moved and also the weight of water required to float the boat, which would be an additional load of about 115 tons, and would require an additional expenditure of water in the same ratio for like movements of boats. In the case of a double-track plane with caissons, the same increase in expenditure of water would be necessitated; but in the case under discussion, that system of arrangement *must* be established that expends the least quantity of water.

In whatever manner the comparison may be made between the lock-system and the inclined-plane system, either of single locks and single-track planes, or of double locks and double-track planes, the economy in construction and in the expenditure of water is pre-eminently in favor of the inclined planes.

Stationary steam-engines could be substituted for the turbine motors, but their cost would be \$15,000 additional at each plane. They would be more liable to accident, and require skilled superintendence and the constant expense of fuel, while, on the contrary, they would avoid the expenditure of water needed to operate the turbines.

EFFECT ON COST OF TRANSPORTATION.

Taking the operations of the completed canal between Cumberland and Georgetown as a basis of cost, a careful analysis of the cost of transporting coal shows a cost of 0.4 cent per ton per mile, exclusive of tolls, when the rate of transportation is 1.7 miles per hour, or at the rate of 0.68 cent per hour of time, and consequently a saving of 30½ hours' time works a saving of 20.8 cents per ton between Connellsville and Cumberland, an equated saving of fifty-two miles in distance by the system of inclined planes, in comparison with the system of lift-locks as herein compared.

Very respectfully,

Maj. WM. E. MERRILL,
U. S. Engineers, Brevet Colonel, U. S. A.

THOMAS S. SEDGWICK.

N 9.

SURVEY OF THE YOUGHIOGHENY RIVER, PENNSYLVANIA.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, August 14, 1874.

GENERAL: I have the honor to forward herewith Lieutenant Mahan's report on the survey of the Youghiogheny River, as ordered by the act of March 3, 1873.

The cause of the delay in getting this report before Congress is explained in the report itself.

Having no special instructions as to the limits of the survey I directed Lieutenant Mahan to commence at West Newton and work down stream to the mouth of the river. I selected West Newton as the starting point because I understood that the wishes of those at whose instance this survey was ordered were to have an extension of the Monongahela slack-water system up the Youghiogheny; and therefore I thought it best to limit the survey to a length of river that could be examined thoroughly, and not to go above a point that could be reached by three dams of 10 feet lift each, believing that there would be ample time to continue the survey after these dams were built. I had no instructions to make this survey a part of the examination for the extension of the Chesapeake and Ohio Canal route, and therefore treated the question as a purely local one.

After the estimate for an improvement by permanent dams had been made, I directed Lieutenant Mahan to make another estimate for the construction of movable dams, on the model of that across the Seine at Port-à-l'Anglais. I did not expect that this system could be advantageously applied to the Youghiogheny, but I thought that it would be a valuable study for similar work on the Ohio.

The mouth of the Youghiogheny is in the second pool of the Monongahela, and, therefore, boats descending the former stream must pass two locks before reaching free navigation in the Ohio. For this reason, and for its increased cost, I would not recommend an improvement on the Youghiogheny by movable dams.

The most serious question in improving this river comes from the scantiness of its water-supply in summer. On this account the estimate for lock-foundations is particularly large in order to reduce leakage to the minimum.

The estimated cost of slack-water to West Newton, by three locks and dams of 10 feet lift each, is \$688,023.21. This is a larger estimate than is usual for such locks and dams, but it will be seen on examination that the increase of cost arises from the defective character of the foundations.

Accompanying this report are fourteen sheets of maps, giving the plat of the part of river surveyed on the scale of 1 inch to 200 feet, its longitudinal profile, and various cross-sections. There is also a sheet on which is shown, on a small scale, the kind of movable dam on which the estimate was based. The movable parts are Chanoine wickets, and the arrangement is similar to that adopted at Port-à-l'Anglais on the Seine just above Paris.

Respectfully, your obedient servant,

WM. E. MERRILL,
Major of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Report of Lieut. F. A. Mahan, Corps of Engineers.

UNITED STATES ENGINEER OFFICE,
Cincinnati, July 28, 1874.

SIR: I have the honor to submit the following report of the survey of the Youghiogheny River from West Newton to McKeesport:

Having been ordered for temporary duty to the Atlantic coast just two weeks after my return to this office, and not having had with me any maps or other data from which a report could be prepared, I have been compelled to wait until the present

time before completing it, as upon my return I found that certain additions had to be made to the maps, the data for which were to be found only in my own note-book.

The act of Congress approved March 3, 1873, reads as follows, in so far as it concerns this work :

"Sec. 2. That the Secretary of War is hereby directed to cause examinations or surveys, or both, to be made at the following points, namely :

"The Youghiogheny River, Pennsylvania."

Your orders, given to me verbally, were that the survey should extend from McKeesport, at the mouth of the river, to West Newton, about twenty miles up ; consequently nothing was done outside of these limits.

The Youghiogheny rises near the boundary-line of the States of Maryland and West Virginia. Its course is about due north as far as Confluence, where its direction changes to west-northwest, preserving this general direction unchanged until it joins the Monongahela at McKeesport. A few small, unimportant streams empty into it above Confluence, at which point it is joined by its two most prominent tributaries, Castleman's River and Laurel Hill Creek. Below Confluence three other streams flow into it, but they are also very small. The Youghiogheny runs very nearly parallel with the Monongahela ; just below its head-waters it is crossed by the Baltimore and Ohio Railroad. At Confluence the Pittsburgh, Washington and Baltimore Railroad comes on its right bank, which it follows thence to McKeesport. The Pittsburgh, Wheeling and Baltimore Railroad is a branch of the Baltimore and Ohio Railroad, which it joins at Cumberland, Md.

There are no towns of any importance between McKeesport and West Newton. The distances of the principal villages from Pittsburgh are as follows :

	Miles.
McKeesport, on the right bank	15.7
Boston, on the left bank	19.4
Osceola, on the right bank	21.7
Alpsville, on the right bank	22.5
Shauer's, on the right bank	26.2
Buena Vista, on the left bank	27.7
Armstrong's, on the right bank	27.7
Moore's, on the right bank	28.8
West Newton, on the right bank	34.5

In times of very high-water steamboats could go up to West Newton, and perhaps even farther, were it not for the bridge that here crosses the river, and is about 10 feet above high-water.

I could not find any data for determining an average high-water at West Newton, as no one seemed to take any particular notice of the river. The highest water there known occurred on the 7th of February, 1868, and stood at 23.94 feet above low-water. This rise was caused by an ice-gorge in the river below.

The river in times past has been slack-watered, but I have so far been unable to obtain any satisfactory information about its history or its work. I could only find traces of two locks and dams, one about a mile below Osceola, the other at Buena Vista, but they had long been lying in ruins, the dams completely broken through, and the locks almost totally destroyed. Nothing of them is now standing save small portions of the chamber-walls. So far as I could learn from conversation with persons living in the neighborhood of the river, the great cause of failure was in the dams having been built too high. What this height was exactly I could not learn, but the lift from pool to pool was about 13 feet.

The survey was made in August, September, and October of 1873. The force at first consisted of Mr. Hoag, myself, and five men, the number of whom was afterward increased to seven. Considerable delay was caused by the difficulty of obtaining suitable transportation for the party and instruments, but work was finally begun on August 11 and continued until November 1.

The party was divided into two sections. The first, under Mr. Hoag, took in the topographical and hydrographical parts, while the second, under my own supervision, attended to the leveling. The topography was conducted by the ordinary methods of courses and bearings. A system of diagonal time-soundings was made from West Newton to McKeesport, and at all marked shoals lines of triangulated soundings, 200 feet apart, were run perpendicularly to the shore.

The leveling was conducted with the special object of determining the difference of level between the water-surface at West Newton and the water-surface in the second pool of the Monongahela slack-water system. Eleven bench-marks in all were established. They are all cut on rocks and in the form of a Greek cross, the center of the cross being the point at which the rod should be held. The following description of the bench-marks may be useful for future reference :

No. 1. On top of a sandstone guard-post, situated at the intersection of the curbs on

the northeast corner of Main street and the street fronting the river, in West Newton. The block is 18 inches high, horizontal section 14 by 8 inches, top face 12 by 6 inches, B. M. on top face. This bench being the starting-point of levels, its reference was arbitrarily assumed at 250.0. All references in this survey are in feet.

No. 2. A cross cut on the sixteenth stone from the water-front, seventh course from the top, north side of the east abutment of the West Newton bridge. Reference 248,157.

No. 3. A cross cut on the eighth stone from the water-front, twelfth course from the top, north side of the east abutment of the West Newton bridge. Reference 240,209.

No. 4. A cross cut, with a figure 4 alongside, on a large flat stone, about two miles below West Newton, on right bank. The stone is a little to the left of a line through the chimney of a paper-mill at West Newton, tangent to the left bank of the river. The stone is 20 by 9.5 feet, cross is 0.22 foot square, figure 4 is 0.26 foot long. Reference 224,245.

No. 5. A cross cut on the northwest corner of the top foundation-course of the east abutment of the railroad-bridge crossing Sewickly Creek, near its mouth, may be known by a large V cut near the northeast angle of the cross. Reference 225,030.

No. 6. A cross cut on a large stone directly across the river from Suter's Pier, at Sutersville. Reference 221,196. This B. M. is very badly cut, on account of the nature of the stone, which, being slaty in its character, would not work well under the chisel.

No. 7. A cross cut on a large piece of conglomerate, irregular in shape and reddish in color. It is situated on the left bank of the river, about 800 yards below the old slack-water dam at Buena Vista. Reference 214,908.

No. 8. A double cross (+) cut on a large out-cropping boulder on the left bank of the river, a little below Robbins's Run. The point of rest for the rod is at the cross nearest the channel. Reference 206,453.

No. 9. A cross cut near the top of a large stone on the left bank of the river. Above the cross is an arc of nine small holes drilled into the stone, which is situated midway between the Alps House (a large hotel at Alpsville, on the right bank) and the Coultersville Baptist church, a very prominent frame building, with long windows, standing near the southwest end of Alpsville. Reference 211,291.

No. 10. A cross, surmounted by a letter X, on a flat stone lying on the right bank, between the coal-tipples of N. J. Bigley and Brown & Cochran. Reference 200,863.

No. 11. No description will be here given, as it has since been destroyed.

No. 12. A cross cut on a large stone on the left bank of the river, almost in the prolongation of Sixth street, McKeesport. Reference 206,309.

The above description will, I think, be sufficient to enable any one to determine the location of any of the benches without difficulty.

In determining the difference of level between the water-surface at West Newton and at McKeesport, the rule was adopted to repeat on the morning of each day the work done on the preceding afternoon. After reaching the end of the work, it was gone over twice from end to end, continuously, for the purpose of checking. On account of my having been laid up sick, the final leveling was done by Mr. Hoag, and our work agreed within five-hundredths of a foot. The difference of level found was 25.427 feet. From this subtract 1.1 feet, the depth of water at the bridge, and we obtain 24.3 feet as the difference of level between the Monongahela pool and the bottom of the river at West Newton. A depth of 6 feet at West Newton would give the water-surface 30.3 feet above the Monongahela pool. This can be divided into three pools, requiring a lift of 10 feet to pass from pool to pool. The remaining 0.3 could be removed by dredging.

Owing to the low stage of water, the bottom of the river was distinctly visible for almost the entire distance from West Newton to Alpsville. The surface of the bottom is formed of gravel, except in a bend just above Sutersville and below the old dams, in which localities the surface-stratum was found to be of sand. As we were unprovided with the necessary boring-tools, we were unable to determine what formation underlay the bottom. This is a question that must be carefully investigated before any final locations for the locks and dams can be decided on.

The discharge of the river was determined by Mr. Hoag at Rattle's Ripple. He made use of surface-floats over a course of 40 feet in length, the average depth of the section being one foot. The amount of discharge he found to be 183 cubic feet per second, which will give 10,980 per minute, or 658,800 per hour. Now, the size of lock proposed for use in this work is that of the large locks on the Monongahela. The chambers of these locks measure 250 feet in length by 56 in breadth. These dimensions, with a lift of 10 feet, give 140,000 feet as the amount of water required for one lockage. About twenty minutes is needed for a boat to pass one of these locks, or three boats can pass in an hour, requiring 420,000 cubic feet of water in the same time, and leaving a surplus of 238,800, or $\frac{1}{4}$ of a prism of lift. Now, when the river was gauged, although it was very low, it was not at its lowest stage, and, judging by information furnished me by the inhabitants in conversation, I am inclined to think that the supply in a dry season must be so scant that it would hardly be sufficient. On this point, however, it was impossible to obtain reliable data, as the people living near the river do not seem to study its movements with any care. Granting, however, that this supply (183 cubic

feet per second) can be kept up, it will be easily seen that the water must be carefully husbanded, and that a dam of the very best design to prevent leakage will be required, and that the foundation for the lock must be made very tight, in order that the water may not escape through it.

To form three pools three dams will be required. As the exact location of each dam has not been determined on, I have only been able to *assume* a length for each one. Taking that point on each pool where there will be 6 feet of water, and measuring the distance from the top of the bank on one side to the top of the bank on the other, we find the sum of the three distances to be 1,850 feet, which, deducting 85 feet for width of lock, gives the total length of the three dams of 1,595 feet, or an average length of 532 feet for each dam.

These dams I propose to construct as follows: 1st. To build strong timber cribs, about 6 feet in height and 50 feet in width, and place them in line across the stream. 2d. To drive a row of heavy square piles along the down-stream side of the cribs, for the purpose of keeping them in position, the tops of the piles to be flush with the upper surface of the cribs. 3d. To drive on the up-stream side of these cribs two rows of 8-inch sheeting-piles in juxtaposition, the rows to break joints. These piles to be driven so that their tops shall be flush with the top surfaces of the foundation-cribs, the up-stream row of sheeting-piles to support the lower ends of the timbers composing the apron of the dam. 4th. To build a strong crib on top of these foundation-cribs, and make it a continuous structure from one end of the dam to the other. This super-crib to be 10 feet in height, the down-stream side being built in three steps of 3½ feet each, the up-stream side being an apron formed of heavy timbers, wrought to true faces, and laid as close together as possible. The apron to have a slope of 1 perpendicular to 2.5 base. 5th. The crest of the dam will be formed by a timber 12 by 18, thoroughly bolted and fastened to the crib-work. 6th. To fill in all the crib-work with riprap. 7th. To cover the entire up-stream side of the dam from the top of the apron down with gravel, the top surface of which is to have a slope of 1 perpendicular to 6 base.

ESTIMATE FOR ONE DAM 532 FEET IN LENGTH.

14,167 linear feet of piles, 12½ cents per foot	\$1,770 87
90,720 feet (board-measure) sheet-piles, at 35 cents per M	3,175 20
848,400 feet (board-measure) timber in crib-work, at \$35 per M	29,694 00*
127,000 feet (board-measure) timber in apron, at \$35 per M	4,445 00
532 piles, driving, at \$2.50 each	1,330 00
1,064 sheeting-piles, driving, at \$2.50 each	2,660 00
11,000 cubic yards riprap, at \$1.25 per yard	13,750 00
10,588 cubic yards gravel, at 40 cents per yard	4,235 20
Total cost of dam	61,060 27

MASONRY ABUTMENT.

At the end of the dam opposite the lock will be an abutment of stone, extending 30 feet above and below the dam, with wing-walls 40 feet in length. The abutment is to be 5 feet thick at the top and 10.5 feet thick at the bottom, the side next the bank to be vertical, the height 22 feet. It is to rest on a foundation of piles in four equidistant rows parallel to the face of the abutment, the piles in each row to be 5 feet apart. A capping-piece 12 by 12 inches will be laid on each row of piles, and the grillage thus formed covered by a platform of 5-inch plank laid crosswise upon it. The top of the platform to be laid on a level with the bottom of the foundation-crib of the dam. On this platform will be built the abutment.

ESTIMATE FOR ABUTMENT.

3,040 linear feet of piles, at 12½ cents per foot	\$380 00
9,120 feet (board-measure) grillage, at \$35 per M	319 20
9,975 feet (board-measure) platform, at \$35 per M	349 13
438 cubic yards quarry-face masonry, at \$9.60	4,204 80
636 cubic yards rubble masonry, at \$7.20	4,579 20
5,000 cubic yards riprap for protecting banks, at \$1.25	6,250 00
152 piles, driving, at \$2.50 each	380 00
Laying grillage	33 00
Laying platform	70 00
Total for abutment	16,565 33

The foundation adopted for the lock is similar to that of the lock recently built at Henry, on the Illinois River, the bed in each case being permeable soil. In this case, however, additional precautions have been taken to guard against leakage on account of the scantiness of the water-supply.

Before going farther it may be well to give a brief description of the Henry lock.

This lock is built entirely in the bed of the river, the center line at the head being 350 feet from the low-water line, and at the foot 150 feet. The earth where the foundation is placed was first removed to a depth of 6 feet. Three thousand two hundred bearing piles 12 inches in diameter were driven so as to have five rows under the entire length of each wall, the piles in each row being 3 feet apart, the remainder of the piles being driven over the chamber space in seven parallel rows, the piles in these rows being also 3 feet apart. Under the head-bay the longitudinal rows are doubled, being fifteen in number. Longitudinal foundation timbers 12 inches square were then placed on these piles and securely bolted to them. Cross-timbers 12 inches square were then laid on these and securely bolted to them, forming a grillage. The spaces between the timbers, and to a depth of 3 inches below, were filled with concrete, thus making a depth of concrete of 27 inches. All the foundation was then covered with 2½-inch plank. Six rows of sheeting-piles were driven across the foundation, the piles being from 4 to 6 feet in length.

The additions I propose to make to the above are, to increase the depth of concrete to 36 inches; to put in ten rows of sheeting piles instead of six; to put at the head of the lock two rows of sheeting piles, 8 feet apart, instead of one, and to fill in the intermediate space with 6 feet depth of concrete; all the sheeting-piles to be 10 feet long instead of 4 to 6 feet.

As the lock here proposed is smaller than the Henry lock, the chamber of which is 250 feet by 75, the number of piles will be reduced from 3,200 to 2,309.

ESTIMATE FOR FOUNDATION OF LOCK 250 FEET LONG BY 56 FEET WIDE.

46,180 linear feet of piles, at 12½ cents per foot	\$5, 772 50
173,440 feet (board-measure) sheeting-piles, at \$35 per M	6, 070 40
42,600 feet (board-measure) sheeting-piles, at \$35 per M	1, 470 00
135,000 feet (board-measure) lower-flooring course, at \$35 per M	4, 375 00
51,050 feet (board-measure) upper-flooring course, at \$35 per M	1, 786 75
8,400 feet (board-measure) binding-strips at \$35 per M	294 00
1,100 cubic yards of concrete, at \$6 per yard	6, 600 00
7,000 cubic yards of earth excavation, at \$1 per yard	7, 000 00
2,309 piles, driving, at \$2.50 each	5, 772 50
1,050 sheet piles, driving, at \$2.50 each	2, 625 00
Laying grillage	550 00
Laying flooring	1, 000 00
Total cost of foundation	43, 316 15

The lock is to be of stone. Dimensions of chamber, 250 by 56 feet; lift, 10 feet; walls, 22.5 feet high, 10 feet thick at top, 13.5 feet thick at bottom; 350 feet total length.

ESTIMATE FOR LOCK.

2,000 cubic yards cut-stone masonry, at \$14.40 per yard	\$28, 800 00
1,200 cubic yards quarry-face masonry, at \$9.60 per yard	11, 520 00
3,513 cubic yards rubble masonry, at \$7.20 per yard	25, 293 60
4,000 cubic yards earth filling, at 50 cents per yard	2, 000 00
1 lift-wall, 167 cubic yards quarry-face masonry, at \$9.60 per yard	1, 603 20
4 gates, complete, at \$4,000 each	16, 000 00
Total cost of lock superstructure	85, 216 80

SUMMARY.

Cost of dam	61, 060 27
Cost of abutment	16, 565 33
Cost of lock foundation	43, 316 15
Cost of lock superstructure	85, 216 80
Cost of one lock and dam, complete	206, 158 55

ESTIMATE FOR ENTIRE IMPROVEMENT.

3 locks and dams, at \$206,158.55 each	618, 475 65
Removing obstacles already existing, as old locks and dams, old bowlder, dams, &c	7, 000 00
	625, 475 65
Add 10 per cent. for contingencies	62, 547 56
Total cost of improvements	688, 023 21

This estimate will carry the full depth of water (6 feet) to the lower end of the town of West Newton. It is possible that a little dredging may be needed near Buena Vista, but it will be small in amount, and as the construction of the dams mentioned might cause the removal of this bar in order to secure a supply of gravel, no account has been taken of it in the estimate.

MOVABLE DAMS.

Another mode of improvement, by means of movable dams, is presented.

The system proposed is the same as that adopted at Port-à-l'Anglais, on the Upper Seine.

The dam on the Youghiogheny will be somewhat longer than at Port-à-l'Anglais, the former being 532 feet and the latter 446.

The movable dam proposed consists of Chanoine wickets, erected in a free pass and on a weir, the pass-wickets being 13 feet high and the weir-wickets 7 feet. The depth of water required at the head of each pool is 6 feet; consequently, we will have a lift of 7 feet from pool to pool.

The pass is assumed at 150 feet in width, requiring thirty-eight wickets, and ninety-five will be required for the remaining 382 feet, which will constitute the weir, the wickets being taken as 4 feet wide.

The use of movable dams reduces the lift of the locks from 10 to 7 feet.

As the total elevation required to give 6 feet of water at West Newton is 30 feet, it is evident that five movable dams will give 35 feet of elevation, or five feet more than is necessary, while four dams will give but 28 feet, or 2 feet less than is needed. If, therefore, the slack-water is to stop at West Newton bridge, we must have either five dams of 6 feet lift or four dams of 7.50 feet lift each. I should recommend the latter. If, however, the slack-water is to be extended indefinitely above West Newton, I would recommend the construction of five dams with 7 feet lift, believing these dimensions to be the best for general use. The estimates that follow are for movable dams having the last-named lift. The comparison of cost is, therefore, somewhat unjust to the latter system, as it actually gives 5 feet more elevation than the former.

ESTIMATE OF COST.

For a movable dam, constructed like that across the Upper Seine at Port-à-l'Anglais, height of wickets, 13 feet; lift of locks, 7 feet; breadth of wickets, 4 feet:

NAVIGABLE PASS.

Cost of foundation per running foot.

3.52 cubic yards cut-stone masonry, at \$14.40.....	\$50 69
11 cubic yards rubble masonry, at \$7.20.....	79 20
3.13 cubic yards riprap, at \$1.25.....	3 91
7.30 cubic yards concrete, at \$6.....	43 80
64 feet (board-measure) of sill, at \$35 per M.....	2 24
1,500 feet (board-measure) piles, &c., for coffer-dam, at \$35 per M.....	52 50
Total cost per running foot.....	<u>232 34</u>

Cost of trestle of pass.

1 trestle, 1,300 pounds, at 10 cents.....	\$130 00
2 journal-boxes, 130 pounds, at 7 cents.....	9 10
2 anchoring-rods, 133 pounds, at 10 cents.....	13 30
1 anchoring-disk, 80 pounds, at 7 cents.....	5 60
2 claw-balks, 120 pounds, at 10 cents.....	12 00
1 hand-rail post, 12 pounds, at 10 cents.....	1 20
Cost of trestle, complete.....	<u>171 20</u>

Cost of wicket of pass.

1 horse, 450 pounds, at 10 cents.....	\$45 00
2 anchoring-rods, 133 pounds, at 10 cents.....	13 30
1 anchoring-disk, 80 pounds, at 7 cents.....	5 60
1 prop, 600 pounds, at 10 cents.....	60 00
4 journal-boxes, 220 pounds, at 7 cents.....	15 40
310 feet (board-measure) lumber for panel, at \$50 per M.....	15 50
Cost of wicket, complete.....	<u>154 80</u>

Cost of the sole.

1 hurter and slide, 480 pounds, at 10 cents	\$48 00
1 tripping-rod, 98 pounds, at 10 cents	9 80
2 guides, 42 pounds, at 10 cents	4 20
1 roller, 26 pounds, bronze, at 40 cents	10 40

Cost of sole and appurtenances	72 40
--------------------------------------	-------

Total cost of one section 4 feet wide of the pass, excluding the foundation.

Trestle, complete	\$171 20
Wicket, complete	154 80
Sole and appurtenances	72 40
Chains, bolts, &c., not considered in the above	50 00

Total cost of one section	448 40
---------------------------------	--------

Or, per running foot	\$112 10
Cost of foundation, per running foot	232 34

Cost of pass, per running foot	344 44
--------------------------------------	--------

Cost of pass, 150 feet wide, \$51,666.

WEIR.*Cost of foundation of weir, per running foot.*

1.10 cubic yards cut stone, at \$14.40	\$15 84
2.50 cubic yards rubble, at \$7.20	18 00
3.70 cubic yards riprap, at \$1.25	4 63
5.50 cubic yards concrete, at \$6	33 00
64 feet (board-measure) of sills, at \$35 per M.	2 24
2,000 feet (board-measure) piling, &c., at \$35 per M	70 00

Total cost per running foot	143 71
-----------------------------------	--------

Cost of trestle and wicket of the weir.

There being no data of the weights and dimensions of the wickets of the weir, I assumed that, as they are about three-fourths as high as the wickets of the pass, they would probably cost about three-fourths as much.

Those of the pass (including the trestles) cost \$112 per running foot, hence those of the weir should cost per running foot about	\$94 00
To this add the cost of foundation per running foot	143 71

Cost of weir, per running foot	227 71
--------------------------------------	--------

Cost of weir, 382 feet long, \$86,985.22.

Cost of pass and weir.

Cost of weir 382 feet long	86,985 22
Cost of pass 150 feet long	51,666 00

Total cost	138,651 22
------------------	------------

If a maneuvering-boat be used for the weir, we can omit the trestle bridge above the wickets. This would effect a saving of 95 trestles, which, at an average cost of \$128, would amount to \$12,160. From this we must take the cost of the boat, which will be about \$300, leaving a total saving of \$11,860. The suppression of the wickets would also greatly reduce the cost of the foundation of the weir, as the latter would not then be so wide. Assuming that this would reduce the cost of foundation by one-third, we have a saving from this source of \$48 per running foot, or of \$18,336 in the length of the weir.

Under this condition, the total diminution of cost would be—

On the foundation	\$18,336 00
On the trestles	11,860 00

Or, in all	30,196 00
Subtracting this from the cost before given, which is	138,651 22

We obtain as the cost when the boat is used	108,455 22
---	------------

Cost of five dams, giving a total elevation of 35 feet, \$542,276.10.

The locks attached to the movable dams, having a less lift by 3 feet than those in the permanent dams, will cost about one-fifth less than those used with the permanent dams so far as the superstructure is concerned. The foundation will be unchanged. Hence we shall have for cost of the foundation of the lock, \$43,316.15; for the superstructure, \$68,173.44. The cost of the abutment will remain as before.

SUMMARY.

Cost of dam.....	\$108,455 22
Cost of abutment	16,565 33
Cost of lock.....	111,489 59
Cost of one lock and dam.....	236,510 14

ESTIMATE FOR ENTIRE IMPROVEMENT.

5 locks and dams, at \$236,510.14 each	\$1,182,550 70
Removing obstructions already existing	7,000 00
10 per cent. for contingencies	118,955 07
Total cost of improvement.....	1,308,405 77
Total cost of improvement by permanent locks and dams.....	688,023 21

Or the improvement by movable dams will cost more than that by permanent dams by..... 620,382 56

But in this connection we must notice that by the permanent dams we only reach a height of 30 feet above the surface of the second pool of the Monongahela slack-water, whereas by movable dams we reach a height of 35 feet above the same surface.

The cost per foot of lift with the movable dams is..... \$37,333 02
And for the permanent dams it is 22,934 11

Or..... 14,448 91
in favor of the improvement by permanent dams per foot of rise. Hence the cost per foot of rise by the system of permanent dams is approximately only two-thirds of what it would be by movable dams.

In view of the above figures, I would most certainly recommend that the permanent dams be adopted for the improvement of the Youghiogheny River.

Very respectfully, your obedient servant,

F. A. MAHAN,
First Lieutenant of Engineers, U. S. A.

Maj. W. E. MERRILL,
Corps of Engineers, U. S. A.

APPENDIX O.

ANNUAL REPORT OF MAJOR G. WEITZEL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1874.

(Letter of transmittal under Appendix D.)

IMPROVEMENT OF THE FALLS OF THE OHIO RIVER AND LOUISVILLE AND PORTLAND CANAL.

The operations on this work are fully set forth in the report of Capt. M. B. Adams, Corps of Engineers, my assistant, who was, under my direction, in immediate charge of the work. The following is a copy of his report:

Report of Captain M. B. Adams, Corps of Engineers.

UNITED STATES ENGINEER OFFICE,
Louisville, Ky., June 30, 1874.

GENERAL: In accordance with your instructions, I have the honor to make the following report of operations on the Louisville and Portland Canal enlargement, and the improvement of the falls of the Ohio, for the year 1873-1874:

During the past year the work carried on under the above heading was done in part by contract and partly by hired laborers. That by contract was done by the firms, Boyle & Roach, (contractors for constructing the guide-wall and for excavating below the new locks;) Sheehan & Loler, (contractors for completing the retaining-walls and grading the slopes;) and M. S. Lord, (contractor for constructing outer protection-wall.) M. S. Lord completed his contract in August, 1873; Boyle & Roach completed theirs in October, 1873; and Sheehan & Loler theirs in November, 1873. The entire amount of work done under each of these contracts was as follows, viz:

Under M. S. Lord's contract.

	Cubic yards.
Earth excavation	45, 074
Dry-wall masonry	3, 895

Under Boyle & Roach's contract.

Earth excavation	31, 985
Rock excavation	17, 230
Stone filling	2, 862
Masonry	4, 797

Under Sheehan & Loler's contract.

Earth excavation	52, 100
Dry wall	13, 034
Paving removed	150

Within the fiscal year, under each contract, the following amount of work was done:

M. S. Lord.

	Cubic yards.
Dry wall	346
Filling behind wall	53

Boyle & Roach.

Earth excavation	1, 255
Rock excavation	2, 296
Stone filling	1, 128
Masonry	180

Sheehan & Loler.

Earth excavation	46, 044
Dry wall	5, 846

The work that was done by hired laborers consisted in the excavation of a channel-way through a rock reef below the new locks out into the main river-channel; the excavation of a portion of a rock reef along the apron-dam at the head of the canal, and the construction of the dam at the crest of the falls. This work was advertised three times, and, the bids in each case being considered high, it was finally decided to do the work by hired laborers.

The following extracts from the monthly report for October, 1873, will, it is thought, explain the progress and results of the work under the labor-system, viz:

"During the month a coffer-dam was finished, which in all extended a distance of about 1,150 feet along the apron-dam leading into the canal, and at a distance from that dam of about 100 feet in the extreme. The amount of stone that would require removing within this area, in order to reach grade, is [was] about 4,600 cubic yards. The area was divided into three rooms, by cross or partition walls of earth, in order to make the power of our pumps more sure, and to better provide against accident from a break in the dam. The first section of 400 feet was entirely surrounded with an earth dam, which was not found to be as economical a structure as one of earth and timber combined, even when built in 5 feet of water, and when the earth was costing only 25 cents per cubic yard, (in dam.) All the stone within the first, and about half of that within the area of the second, room was removed during the month, making a total of about 1,600 cubic yards removed.

Six hundred feet of the crib-work for the dam along the crest of the falls was constructed, and about 500 feet of this was filled with the stone from the excavation, the rest of the excavated stone being used to replace the riprap in front of that portion of the dam already constructed. This riprap was carried away by the ice-flood of last winter,

(1872,) and in order to secure the new riprap, the outer layer of stone was placed on edge, (or paved,) the stone fitting in close to each other and being further secured by resting some of the largest stones from the excavation against the last course at the bottom of the slope.

It was the intention to have had this work all made secure in the manner as described above before the close of the season, but the very sudden rise in the river left it only in part done. There remains about 100 feet of crib-work to be filled with stone, and there was not more than 300 feet of the paved riprap that was secured with the large stones along the lower course.

At the foot of the canal, during the month, a coffer-dam was constructed of timber and earth, surrounding an area of 200 feet by 400 feet, from within which it was the intention originally to have removed about 3,000 cubic yards of stone, making a "150-foot channel" through the rock reef that extends across the steamboat channel out into the river from the new locks. Within this area the work of excavating the stone was commenced on the 17th of the month, and between that time and the morning of the 26th there were 1,500 cubic yards of stone removed. The water then broke into the dam and prevented any further work. The channel resulting from this work gives a clear passage-way down to grade of 90 feet in width in the narrowest place.

Total expense on upper excavation.....	\$14, 138 22
Cost per yard of stone removed.....	8 23
Total expense of lower excavation.....	13, 977 49
Cost per yard of stone removed.....	9 32
Total cost of dam.....	7, 058 42
Cost per foot.....	11 76

As the river remained up, all further work on the dams, filling of crib-dam and the like, was prevented. The coffer-dam surrounding the upper excavation was allowed to remain through the season, but the lower one was taken up through the kind assistance of the superintendant of the canal, who sent his dredge-boat to our relief. The material was caught and brought to shore, and afterward taken to the Jeffersonville yard and stored there. About half of the coffer-dam left in over winter was carried away by the high water. The material saved from the other one will be all that is required for the next season's work, (to surround and complete the upper piece of excavation.) The riprap dam has again been carried away where it was not well secured with paved face and heavy stones at the base of the slope.

The dam between the head of Sand Island and the Indiana shore will require repairs, as reported in my monthly report for May, 1874. There being nothing further to report,

I remain, very respectfully, your obedient servant,

M. B. ADAMS,
Captain of Engineers, U. S. A.

General G. WEITZEL,
Major of Engineers, U. S. A.

As stated in my last annual report, the sum of \$100,000 is still needed to complete this work as originally designed. The delay in making this appropriation has already done harm to the unfinished parts of the work, and will continue to do so if this appropriation is not made at once. It is needed to complete the rock excavation at the head and foot of the canal, to complete the dam on the crest of the falls, and to raise the protection-wall at the upper end of the canal.

The original estimate for the cost of this work, as stated in my annual report for the fiscal year ending June 30, 1870, was \$1,243,500. There has been allotted and appropriated for the work as follows:

1868, allotted.....	\$35, 000
1869, allotted.....	178, 200
1870, appropriated.....	450, 000
1871, appropriated.....	250, 000
1872, appropriated.....	300, 000
1873, appropriated.....	100, 000

1, 363, 200

Of this amount \$1,335,983.60 has been expended. As above stated the additional sum of \$100,000 will be required to complete the work, making its cost \$1,463,200, instead of \$1,243,500. The difference is,

in round numbers, about \$220,000, and this excess in cost is entirely due to the manner in which the appropriations were made. If these had been made as I recommended, I am certain that I could have built the work in three summers, and for a sum less than my estimate.

The total amount of work done during the fiscal year was as follows, viz :

Dry wall built, cubic yards	6,292
Earthwork, (excavation and filling,) cubic yards	47,354 +
Rock excavation, cubic yards	5,396
Stone filling, cubic yards	1,128
Masonry, cubic yards	180

The amount that can be profitably expended on this work during the next fiscal year is \$100,000.

The work is located in the third collection-district of Kentucky. The nearest port of entry is Louisville.

The amount of revenue collected at this port during the last fiscal year was \$82,054.44.

The commerce and navigation of the Mississippi River and all its branches will be benefited by the completion of this work.

Financial statement.

Balance in Treasury of United States July 1, 1873	\$149,989 00
Amount in hands of officer and subject to his check, (including \$20,889.17, percentage due on contracts not yet completed)	31,501 18
Amount expended during the fiscal year ending June 30, 1874	154,273 78
Amount available July 1, 1874	27,216 40
Amount required for the fiscal year ending June 30, 1876	100,000 00

APPENDIX P.

ANNUAL REPORT OF MAJOR WALTER McFARLAND, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1874.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., September 12, 1874.

GENERAL: I have the honor to transmit herewith my annual reports for the year ending June 30, 1874.

Very respectfully, your obedient servant,

WALTER McFARLAND,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers.

P 1.

IMPROVEMENT OF THE TENNESSEE RIVER.

This improvement, as in the preceding year, has been carried on exclusively by the use of hired labor, and with the usual good results. No time has been wasted through inadequacy of outfit or supplies, and the work has been well done, the dams particularly offering a marked contrast to those built under the contract system, the stone being larger and more compactly placed, which enables them to resist better the

shock of floating bodies, while their greater tightness gives a better depth of water in the channels which they are designed to improve.

In both the upper and the lower river work has been carried on only at the points where it had previously been begun, the appropriations not being large enough to justify the commencement of new work, although this is greatly to be desired.

On the 13th of January, the building in which was situated the United States engineer-office at this place was destroyed by fire, and with it were destroyed a number of instruments, books, records, and maps; amongst the latter were the results of seven months' work on the detailed surveys for the Muscle Shoals Canal, consisting of sketches and detailed estimates needed for beginning the repair of this work. This was the most serious of our losses, as it involves the necessity of going over all this field-work again, and produces a delay of several months at a season when we ought to be at work. It is hoped that this loss will be repaired in time to admit of the beginning of the work early in the fall.

TENNESSEE RIVER ABOVE CHATTANOOGA.

The works are mentioned in their order, beginning at the one nearest Chattanooga.

Sanda Shoals.—The dams here are completed; aggregate length, 4,984 feet; 9 feet wide at top, and averaging 4 feet in height. The effect has been to give 12 inches more water at the head of the shoals, which is at the foot of Sanda Island; the gain diminishes, however, to nothing at the foot of the lower dam. A small amount of excavation remains to be done at the foot of the island; and in order to gain a sufficient depth of water in that part of the channel which is not affected by the dams already built, it will be necessary to build here an additional dam, at a probable cost of \$6,000. Steamboats have, however, passed this obstruction regularly all this spring and summer, the river having been sometimes within 6 inches of the lowest stage.

The name of this obstruction has been misprinted in previous reports *Sandy* instead of *Sanda*.

Kelly's Shoal.—Very little done; about 30 cubic yards of rock removed from the channels.

Watts's Bar.—Only a small amount of rock-excavation has been done here this year. About one-quarter of the whole amount remains to be done.

White's Creek Shoals.—This work, as ordered, has been completed. The whole length of dam constructed here is 3,910 feet; variable width in some places, 12 feet; and in one place built in 13 feet depth of water. Some of the stone used in this dam were much exposed to the impact of drift-logs; weight from two to three tons apiece.

This improvement is completely successful, there being now $3\frac{1}{2}$ and 4 feet depth in the channel where formerly there was a depth of but 18 inches and 2 feet. Three years ago this was the most serious obstacle in this part of the river, being the first to close navigation when the river fell. A sand-bar appears to be forming at the foot of this shoal, and if we find that the scour of the river is insufficient to remove it, it will be necessary to extend the lower dam some 500 feet further down stream, at a probable cost of \$2,500.

Half-moon Shoals.—The improvement at the head of Half-moon Shoals is complete. About 2,000 linear feet of dams have been built, the effect of which has been to give $3\frac{1}{2}$ feet of water in what were formerly the

worst parts of the channel, and to greatly increase the depth for several miles down the chute.

At the foot of Half-moon Island a dam and some excavation in channel will be required, which will probably cost \$3,000.

Shields's Dam.—Nothing has been done here.

King's Bar.—Nothing has been done here.

Turner's Bar.—A small amount of rock-excavation in channel has been done here, leaving about four-fifths of it yet to be completed.

Caney Creek Shoals.—The improvements originally ordered at this point have been completed; but, although we have gained 12 inches in depth, we have not yet secured 3 feet depth, as desired, there not being more than 28 inches in the channel at low water. Another dam will have to be constructed at the foot of these shoals in order to give the desired depth. The probable cost of this dam is \$5,000.

Long Island Shoals.—The rock for the dams has been quarried, and the work is about half finished.

Seven Island Shoals.—All the stone required for the dams at this point has been quarried, leaving about two-thirds of the work yet to be done.

Wilson's Island Shoals.—All the stone needed in the dams is quarried, leaving about two-thirds of the whole work yet to be done.

Bacon's Shoals.—Nothing has been done here.

Bogart's Shoals.—A dam 575 feet long has been built, and half the channel-excavation has been finished.

Sweetwater Shoals.—About 1,000 linear feet of dams have been built, and 500 are yet to be built. An increase in channel-depth of 9 inches has been gained.

Harrison Shoals and London Shoals.—Nothing has been done here.

The character of the work done is well indicated by the fact that, although during the past winter these dams, with a united length of three miles, have been subjected to the almost continuous action of heavy freshets, loaded with trunks of trees and other heavy floating objects, the damage which they have sustained is so slight that not more than 200 cubic yards of stone would be required to repair them.

Until the interstices between the stones of which they are composed are filled by the drift, the whole effect of these works cannot be ascertained. This tightening of the dams will also strengthen them; and Mr. Hampton, the very able assistant engineer, who has supervised the work on the Upper Tennessee, proposes to further strengthen them by planting willow-twigs upon them. This was tried last year at Sanda Shoals, Half-moon Shoals, and Caney Creek Shoals; and about one-third of the twigs are still alive and flourishing, which is quite a fair result.

The chief difficulty that has been experienced in conducting this work arises from the sudden changes occurring in the stages of water in the river. A slight rise is commonly sufficient to put an end to channel-excavation, and work upon the dams is often stopped in the same way. Where the rise seems likely to last for a time, it is often necessary to disband the working-parties, as their subsistence, while idle, would increase too much the cost of the work, and some delay is of course experienced in re-organizing them again.

Some injury has been done to the dams by thoughtless people in making passages through them for their canoes. These gaps are apt to increase in size and to diminish the effect intended to be produced by the dams. There is probably no remedy for this, except united action on the part of steamboat-men and others who are engaged in the navigation of the river, and who from their occupation are better able

than any one else to ascertain who are the mischief-doers, and to make known to those who live along the river the danger to navigation of such injuries.

The estimates heretofore given for the improvement of the Tennessee River between Chattanooga and Knoxville are to be found in the reports of Capt. L. C. Overman, Corps of Engineers, dated August 9, 1871, and January 5, 1872, contained in the Annual Reports of the Chief of Engineers for the years 1871 and 1872, at pages 502 and 488 respectively.

It will be observed that these estimates are based upon rapid examinations of the river, the first, between Chattanooga and Kingston; the second, between Kingston and Knoxville; and were intended to be but approximations. The more careful examination of the river by a party specially organized for the purpose, which has been begun under the recommendation of the Senate Select Committee on Transportation-Routes to the Seaboard, will give us the means of correcting those estimates, and in the meanwhile, as a convenience for future reference, I will give here an abstract of Captain Overman's estimates.

In the first estimates, for points lying between Chattanooga and Kingston, the quantities only of work to be done are given, and no prices. I have, however, given the prices for which the work could have been done under the lowest bids received for a part of the work as advertised, as given in the Report of the Chief of Engineers for 1872, page 484. In this estimate, nothing was allowed for contingencies or supervision of work.

In the second estimate, for points lying between Kingston and Knoxville, I have added the 60 per cent. mentioned as the increased cost of a three-foot channel over a channel but 2½ feet deep.

The points mentioned are taken in order, beginning with that one which lies nearest to Chattanooga.

Chattanooga to Kingston :

Sanda Shoals.....	\$6, 100 00	
Kelly's Shoals.....	4, 425 00	
Watts's Bar.....	1, 087 50	
White's Creek Shoals.....	6, 475 00	
Half-moon Shoals.....	8, 450 00	
Shields's Dam.....	4, 562 50	
King's Shoals.....	5, 606 25	
Turner's Bar.....	2, 725 00	
Caney Creek Shoals.....	7, 725 00	
		\$47, 156 25

Kingston to London :

Long Island Shoals.....	4, 000 00	
Seven Islands Shoals.....	5, 120 00	
Wilson's Island Shoals.....	3, 680 00	
Bacon's Shoals.....	1, 984 00	
Bogart's Shoals.....	5, 280 00	
Sweetwater Shoals.....	8, 000 00	
Harrison's Shoals.....	1, 280 00	
London Shoals.....	1, 280 00	
		30, 624 00

London to Knoxville :

Bonder's Shoals.....	2, 560 00	
Lenoir's Shoals.....	6, 080 00	
Bell Canton's Shoals.....	960 00	
Bustle's Bar.....	2, 560 00	
Sister Island Shoals.....	2, 400 00	
Coulter's Island Shoals.....	5, 120 00	
Chota Island Shoals.....	10, 240 00	
Russell's Shoals.....	9, 920 00	

Little River Shoals.....	\$9,200 00	
Williams's Shoals.....	5,360 00	
Lyon's Island Shoals.....	5,760 00	
Knoxville Shoals.....	1,120 00	
	61,280 00	
Superintendence, contingencies, &c., (making the sum of these last two estimates \$125,000, as in the original report)	33,096 00	
		\$94,376 00
		172,156 25

Which is the original estimated cost of the improvement of the Tennessee River between Chattanooga and Knoxville, exclusive of a part of the contingent expenses.

In my reports I have usually assumed the cost of improving this part of the river at..... \$175,000 00

There have been appropriated already for this part of the river the following sums:

From the appropriation of \$80,000 for the improvement of the Tennessee River below Chattanooga, act of July 11, 1870, modified by the second section of the river and harbor bill approved March 3, 1871.....	\$35,000 00	
Act of June 10, 1872.....	25,000 00	
Act of March 3, 1873.....	25,000 00	
Act of June 23, 1874.....	25,000 00	
		110,000 00
Yet to be appropriated.....		65,000 00
		\$110,000 00

From the sum of these appropriations, namely..... the following amounts have been paid:

For the fiscal year ending June 30, 1873.....	\$40,472 40	
For the fiscal year ending June 30, 1874.....	45,389 03	
		85,861 43
Unexpended balance.....		24,138 57

This balance will be entirely exhausted before the close of the present calendar year.

It should be remembered that the estimates for the cost of improving this part of the river were based upon examinations or reconnoissances only, and it is quite possible, therefore, that the more minute examination or survey now being made may develop the necessity for more work than was contemplated when these estimates were made.

This necessity has already shown itself at the following points where we have been working, and where additional dams are needed:

Santa Shoals, additional dam.....	\$6,000 00	
Watts's Bar.....	5,000 00	
White's Creek Shoals.....	2,500 00	
Caney Creek Shoals.....	6,000 00	
Total.....		19,500 00

I have not thought it necessary at present to add this and the contingent expenses, omitted in the first estimate, to the \$175,000 first taken as the estimated cost of this improvement, because the whole of that sum has not yet been appropriated; and until it has been, and there is actual need for more besides, it will be sufficient to indicate simply the possible necessity for going beyond the amount first called for.

TENNESSEE RIVER BELOW CHATTANOOGA.

For the reason given in my last annual report, namely, the greater necessity for the speedy completion of the works above Chattanooga,

not so much time has been given to the works immediately below Chattanooga, which are under the supervision of the same civil assistant.

Ross's Towhead.—About 700 linear feet of dam have been built at the head of the island, and about a thousand more cubic yards of rock remain to be put in it. The rock for the dam at the foot of the shoal has been quarried, although the dam itself has not been begun. The work here is difficult of construction, by reason of the strength of the current; and the scour of the bottom is so great that far more stone is needed for the dams than was at first supposed necessary. Mr. Hampton reports it as one of the hardest places he has had to manage. The quarries first opened for this work, and which were quite near it, gave out before a sufficient quantity of stone had been obtained, and it became necessary to open another one about three-quarters of a mile farther up the river.

Tumbling Shoals.—About 350 cubic yards of rock have been removed from the channel, and perhaps half as much more is yet to be removed. The current here is very swift, and is likely always to give trouble, even if all the channel-obstructions are removed. It will be necessary to place here a good capstan and ring-bolts to enable steamers and flat-boats to warp up against the stream.

The Suck; the Pot.—Nothing has been done at either of these obstructions during the year, and but little remains to be done under the original schemes for their improvement, except the removal of the *débris* left by the contractor, and the completion of a small amount of work left unfinished by him.

Muscle Shoals.—For the reason given in my last annual report, namely, the utter inadequacy of the appropriation, no work of construction has been attempted here. The appropriation of June 23, 1874, of \$100,000 for the improvement of the Tennessee River below Chattanooga, including the Muscle Shoals, in addition to the balance of the appropriation for the preceding year, although not nearly sufficient to enable us to do justice to the undertaking, would have enabled us to begin work at once but for the unfortunate destruction of the records of last year's detailed surveys in the burning of our office in the early part of the year. A party is now in the field engaged in the preparation of new data for the beginning of this work, and before the close of the year I expect to be able to report progress upon the repair of the old canal around Big Muscle Shoals, lying between Lamb's and Campbell's Ferries, twenty-one miles and seven miles, respectively, above Florence, Ala.

I must, however, repeat the statement made in my last annual report, that it is absolutely impracticable to conduct this work either satisfactorily or economically with such relatively small appropriations. The preliminary expenses of a work of this magnitude, in the procurement of tools and the construction of works of protection, will exhaust too much of the money so far appropriated to admit of much progress in the work proper; and to omit these temporary protections would be simply to invite the destruction of any work which might be undertaken without them. This work ought not to be begun with a working fund of less than \$500,000, and much more than this could be expended annually to the profit of the work.

The expensive system of making a large number of small annual appropriations for a work, instead of a smaller number larger in amount, is certain in the end to make the actual cost of the work exceed its original estimated cost.

Colbert Shoals.—The work of removing rock from the channel across

Hoop-pole Reef, and of constructing the dams provided for in the original specifications, was continued to completion in the early part of the fiscal year.

In the course of operations here it was found advisable to remove more rock from the channel than had been at first intended, and to tighten, and in some cases to rebuild, the dams that had been previously built under contract. Nowhere on the river is the difference between the work done by hired labor and that done under contract more conspicuous than here. While the dams built under the former system are regular, solid, and tight, those built under the latter system are crooked, loose, and weak, and must, without exception, be rebuilt. During the winter-freshets a large part of the dam built by the contractor at the head of Colbert Island has been carried away, while its extension, built under the hired-labor system, and more exposed to the shock of the waters than the other part, has stood uninjured. The whole amount of work originally ordered at this point has been done, but the effect expected from it has not been attained, because the dams first built are so loosely put together that very much of the water which they were designed to retain escapes through them. To put these dams in such order as they should have been put in originally, and to rebuild the parts which have been carried away, will make a large addition to their original cost, which must come out of the appropriation for the improvement of the Tennessee River below Chattanooga. A force is now engaged in repairing the break in the dam, which is of such a nature and in such a position that it is dangerous for boats to attempt the passage of the channel in its present condition.

The proper construction of these dams, in the first instance, which could have been secured by the employment of hired labor, would have resulted in a saving of all it will cost now to put them in order, which will probably amount to one-half their original cost. There is no kind of construction which can so little afford to be neglected as this water-work; but it is next to impossible to have it done as it should be done, unless the entire control of it is kept in our own hands, and the workmen are made to feel an interest in their work and to take some pride in it.

No very close examination has ever been made of the probable cost of improving this part of the river, lying between Chattanooga, Tenn., and Paducah, Ky., with the exception of Muscle Shoals, the cost of a canal around which has been estimated at \$4,003,000.

A hasty examination of some of the other obstructions in this part of the river was made in 1868, but it was not sufficiently in detail to admit of the formation of very reliable estimates of the cost of improving them. The detailed examination now being made of the whole river, from Knoxville, Tenn., to Paducah, Ky., with a view to its improvement, will furnish the necessary data for this purpose.

The amounts heretofore appropriated for the improvement of this part of the river are as follows, viz:

Allotted from the general appropriations for rivers and harbors—	
In 1868	\$85,000 00
In 1869	40,500 00
From the appropriation of \$80,000, act of July 11, 1870.....	45,000 00
Act of June 10, 1872	50,000 00
Act of March 3, 1873	100,000 00
Act of June 23, 1874	100,000 00
Total	420,500 00
And there have been expended in the year ending—	
June 30, 1869	\$15,239 69
June 30, 1870	47,429 40

June 30, 1871.....	\$36, 149 86
June 30, 1872.....	21, 274 42
June 30, 1873.....	53, 673 30
June 30, 1874.....	60, 835 41
Withheld for taxes, 1871.....	500 00
	\$235, 102 06
Unexpended balance.....	185, 397 92

During the past year the efforts of J. H. Dennis, of Louisville, Ky., to secure the payment to him of the percentage forfeited by his failure to fulfill his contracts for the improvement of the Tennessee River have been successful, and, upon the recommendation of the assistant judge-advocate-general, approved by the honorable Secretary of War, January 3, 1874. I was directed by letter from the Office of the Chief of Engineers, dated January 5, to pay to Mr. Dennis, through the attorney who prosecuted the claim, the amount of the percentage withheld under said contract. I accordingly transmitted to Mr. B. H. Bristow, of Louisville, Ky., Mr. Dennis's attorney, on the 14th of January, checks for \$19,229.79, the whole amount of the percentage which had been retained under Mr. Dennis's contracts, and their receipt was acknowledged under date of January 16, 1874.

When this percentage was forfeited through Mr. Dennis's failure to fulfill his contracts, I was directed by letter from the office of the Chief of Engineers, dated July 1, 1872, to carry on the work of improvement "by hired labor to the extent of the balance of the appropriation available therefor, including the forfeited percentage." Under this authorization the amount of this percentage had already been expended in the additional work of repair required in the lower river, and the appropriation, therefore, is now diminished by just this amount.

I observe that in the last annual report upon the improvement of the Tennessee River I have made an error in giving the relative amounts expended upon the two parts of it, above and below Chattanooga, respectively. This arose from accidentally including among the expenditures for the fiscal year ending June 30, 1873, amounts which had been expended since the close of that year and before the date of my annual report.

In this report this error is corrected, and the financial condition of both works is accurately given.

The amounts of money which are required and which can be profitably expended in these improvements during the year ending June 30, 1875, are as follows, viz :

For improving the Tennessee River above Chattanooga.....	\$65, 000 00
For improving the Tennessee River below Chattanooga, including the Muscle Shoals.....	750, 000 00
Total	815, 000 00

The nearest port of entry is Louisville, Ky. The amount of revenue collected there is unknown to me.

The commerce of all the States bordering upon the Tennessee and its tributaries, namely, Virginia, North Carolina, Georgia, Alabama, Mississippi, Tennessee, and Kentucky, will be favorably affected by its improvement.

Financial statement.

ABOVE CHATTANOOGA.

Balance in Treasury of United States July 1, 1873.....	\$25, 000 00
Amount in hands of officer and subject to his check.....	19, 527 60
Amount appropriated by act approved June 23, 1874.....	25, 000 00
Amount expended during the fiscal year ending June 30, 1874.....	45, 339 03
Amount available July 1, 1874.....	24, 138 57
Amount required for the fiscal year ending June 30, 1876.....	65, 000 00

BELOW CHATTANOOGA.

Balance in Treasury of United States July 1, 1873.....	\$130,000 00
Amount in hands of officer and subject to his check.....	16,233 33
Amount appropriated by act approved June 23, 1874.....	100,000 00
Amount expended during the fiscal year ending June 30, 1874.....	60,835 41
Amount available July 1, 1874.....	185,397 92
Amount required for the fiscal year ending June 30, 1876.....	750,000 00

P 2.

IMPROVEMENT OF THE CUMBERLAND RIVER.

Work under the contract for improving this river below Nashville, Tenn., has not progressed during the past year with a satisfactory degree of vigor. Some delay was occasioned during the months of July, August, and September, 1873, by the prevalence of cholera and other diseases, chiefly malarial, in the vicinity of Nashville and Harpeth Shoals, at which latter point the main work under the contract was to be done. But it appears, from reports received from the work, that this was not the sole cause of the delay, but that inadequacy of outfit and want of experience on the part of the contractor himself had much to do with it.

The contract was entered into on the 5th of October, 1872, and was to be completed on the 1st of January, 1873. The operations, consisting of the construction of riprap dams, and the removal of rock, &c., from the channel, were to be conducted at Harpeth Shoals, between Sycamore Creek and Reed's Reef, and the total cost was not to exceed \$18,000. On the 1st of January, 1873, when the whole work should have been finished, but one-sixth of it had been done; but, upon the contractor's application, he was allowed an additional year in which to complete it. At the close of that year, however, his work was yet uncompleted, and he applied for, and received, another extension of time to January 1, 1875.

During the fiscal year ending June 30, 1874, he accomplished about \$11,000 worth of work, and since then he has completed what remained to be done.

On the 9th of October, 1873, I relieved Capt. L. C. Overman, Corps of Engineers, from duty on the improvement of the Tennessee River, and sent him to Nashville to take local charge of the improvement of the Cumberland River, with instructions to urge the work on as much as possible. On the 16th of the same month, in answer to my application, I was authorized by letter from the Office of the Chief of Engineers to prosecute the work of improving the Cumberland River by the use of hired labor, independently of the operations being conducted under the contract. A force of men was immediately engaged and set to work getting out stone for the construction of the additional dams required in this part of the river, and not provided for in the contract. By the close of the fiscal year about 12,000 cubic yards of stone had been quarried for this purpose and moved to the bank of the river, in readiness for boating to the points where the dams were to be constructed. No work of excavation in the channel had been done, because the height of the water prevented this; but preparations were made to begin it as soon after the close of the fiscal year as the stage of water in the river would permit, and it is expected that at the close of the present calendar year the whole amount of rock-excavation in channel and construction of dams required at present at this point (Harpeth Shoals) will be completed. This work has been pushed by Captain Overman with his

usual energy, and the results attained by the use of hired labor appear to have been as satisfactory on the Cumberland, as they have proved to be for the past two years on the Tennessee.

In his report Captain Overman states in relation to this system of conducting work that—

The cost will not exceed contract-prices for similar work, while other advantages of the system strongly recommend its continuance.

In this opinion I need scarcely say, after the testimony I have given in my report upon the Tennessee River, I decidedly agree. It is the system of true economy to the Government and to the vessel-owners.

The total amount required for the improvement of the Cumberland River below Nashville, as reported by Maj. Godfrey Weitzel, Corps of Engineers, (see Annual Report of the Chief of Engineers for the year ending June 30, 1871, page 467,) is..... \$248,821 00

For this work appropriations have been made as follows:

Act of March 3, 1871.....	\$30,000	
Act of June 10, 1872.....	20,000	
Act of March 3, 1873.....	25,000	
		75,000 00

Balance yet to be appropriated.....	173,821 00
-------------------------------------	------------

Out of the amount so appropriated, namely.....	\$75,000 00
--	-------------

The following sums have been expended:

For the fiscal year ending June 30, 1872.....	\$15,901 57	
For the fiscal year ending June 30, 1873.....	8,185 67	
For the fiscal year ending June 30, 1874.....	21,506 04	
Percentage retained.....	1,416 92	
		47,010 20

Available balance.....	27,969 80
------------------------	-----------

One-half of this amount has already been expended since the close of the fiscal year, and it will be entirely exhausted by the close of the calendar year.

In my last annual report I observe there is an error of \$5.25 in the amount reported as expended by me, the amount given being too small by this sum. In this report I have corrected this error, and the amounts now given are exactly correct.

No appropriation has ever yet been made for the improvement of the Cumberland River above Nashville, although the survey of this part of the river was made by Mr. S. T. Abert, under the instructions of Maj. Godfrey Weitzel, United States Corps of Engineers, in 1871, and the cost of its improvement was submitted; Major Weitzel's report is to be found at page 463 of the Annual Report of the Chief of Engineers for the fiscal year ending June 30, 1872. The improvement is a matter of great importance to the people of Nashville and of Middle Tennessee, and I think it should be undertaken at once.

The estimated cost of this improvement, as given in the report referred to, is \$235,331, and I would recommend that at least one-half of this amount be asked for for application during the next fiscal year.

The amounts of money which can be profitably expended in the improvement of the Cumberland River during the next fiscal year are as follows, viz:

For improving the Cumberland River above Nashville.....	\$100,000
For improving the Cumberland River below Nashville.....	175,000
Total.....	275,000

The nearest port of entry is Louisville, Ky. The amount of revenue collected there is unknown to me.

The improvement of the Cumberland River throughout its whole extent would be of the utmost benefit to the States of Tennessee and Kentucky, in aiding the development of the coal-mines to be found in the vicinity of the head-waters of the river, and is, therefore, a question which deserves the attention of the General Government.

Financial statement.

BELOW NASHVILLE.

Balance in Treasury of United States July 1, 1873.....	\$35,000 00
Amount in hands of officer and subject to his check, (including \$319.66 percentage due on contracts not yet completed).....	15,912 76
Amount expended during the fiscal year ending June 30, 1874.....	21,506 04
Amount available July 1, 1874, (excluding \$1,416.92 retained percentage).....	27,989 80
Amount required for the fiscal year ending June 30, 1876	175,000 00

P 3.

IMPROVEMENT OF THE TOMBIGBEE RIVER.

The history of this improvement is as follows:

By act of Congress approved July 11, 1870, the Secretary of War was required to cause an examination or a survey to be made on the "Tombigbee River in Alabama and Mississippi, from its mouth to the head of navigation," and an examination was accordingly made of this river from Columbus, Miss., which was regarded as the head of high-water navigation to its mouth, three hundred and seventy miles below, and fifty miles above the city of Mobile. The report of this examination is contained in the report of Col. J. H. Simpson, Corps of Engineers, dated April 17, 1871, to be found at page 573 of the Annual Report of the Chief of Engineers for the year ending June 30, 1871, which gives the estimated cost of improving this part of the river as \$21,500.

By act approved June 10, 1872, Congress directed an examination or survey of the—

Tombigbee River between Fulton and Columbus, Miss.

And by the same act an appropriation of \$10,000 was made for—

The improvement of the Tombigbee River.

The report of this second survey is contained in my last annual report, and will be found at page 548 of the annual report of the Chief of Engineers for the year ending June 30, 1873. At page 697 of the same annual report will be found the report of Capt. A. N. Damrell, Corps of Engineers, of the work done under this appropriation in the improvement of the Tombigbee River.

By act of Congress approved March 3, 1873, it was directed that—

The \$10,000 appropriated at the second session of the Forty-second Congress for the improvement of the Tombigbee River shall be expended in the State of Mississippi.

But more than half the appropriation had already been expended, and when the work was placed under my direction, there was a balance of but \$4,667.05 to be transferred to me.

In order to determine where this balance could be applied with the best results, I directed Mr. Powhatan Robinson, civil engineer, who had conducted the examination of the river between Fulton and Colum-

bus, to make a personal examination with this view, and his report is so much to the point that I give it entire :

SEPTEMBER 10, 1873.

MAJOR: I beg leave to submit the following suggestions in regard to the application of the unexpended residue of the appropriation to the Tombigbee River. They are made in compliance with your orders of June 13.

In my report to you of an examination of the river from Columbus to Fulton, I attempted to show the impolicy of any expenditure on the river above Columbus, save for the improvement of *high-water navigation*, which I strongly recommended. But it is for the planters on the upper part of the river that this aid is most imperatively demanded, to deliver them from the heavy burden of taxation to which they are subjected to get their produce to market and to obtain their return supplies.

Navigation is *practicable* at high-water from Columbus to Aberdeen, though not good. Moreover, these towns, situated on the river, and only twenty-eight miles distant by land from each other, have each a branch road connecting with the main trunk of the Mobile and Ohio Railroad.

It will be seen, therefore, that the planters in that section possess very superior facilities to those dwelling above.

If the money be expended below Aberdeen, it will be of no benefit to the planters above. If it be expended above, it will inure more or less to the benefit of all. If the high-water navigation be improved up to Cotton-Gin Port, it will tend to relieve the planters above to some extent. It is a very accessible point, located on a high bluff on the east side of the river.

I attended a town meeting of the citizens of Aberdeen, and they were unanimous in desiring that the money should be expended above.

I was invited to a conference with the board of trade at Columbus. They wished to have the residue expended below Columbus in the improvement of low-water navigation. I informed them that I had already determined to recommend its application above Aberdeen, because the work below was more expensive, the benefit to be derived from it was less, but, above all that, their necessities were far less urgent than those of the people above.

They admitted the force of my reasons, and acknowledged that under my instructions I could not well act otherwise.

I shall therefore respectfully advise that the residue be applied from Aberdeen upward in the direction of Fulton, and on the plan suggested in my report, to wit, by removing drifts, logs, stumps, &c., in the bed of the river down to the level of low-water and to a width of 60 feet, and by clearing away the leaning trees on the bank.

I am, major, with great respect, your obedient servant,

POWHATAN ROBINSON,
Assistant Engineer, &c.

Maj. WALTER M. MCFARLAND,
Corps of Engineers.

In accordance with these suggestions, I recommended that the balance of this appropriation be expended in the improvement of the Tombigbee River, between Aberdeen and Cotton-Gin Port, in the manner indicated, and by letter from the Office of the Chief of Engineers, dated November 10, 1873, my recommendation was approved, and I was authorized to do the work either by contract or hired labor, as the one or the other method might, in my judgment, seem best to subserve the public interest.

The method by hired labor was adopted, and Mr. Robinson was assigned to the execution of the work.

Preparations had already been made in anticipation of the approval of the Engineer Bureau, so that there was no delay in getting the work started, and work was vigorously prosecuted up to the 27th of December, when the rain and the rise of the river put an end to the season's operations.

Better progress was made than had been expected, as the working party reached a point on the river five or six miles above Cotton-Gin Port; and some hopes were entertained that the improvement might be carried, before the winter rise occurred, as far up as Barr's Ferry, the point where the road from Smithville crosses the Tombigbee, and through which the benefit of the improvement would first manifest itself

to the citizens of Itawamba County; but in this hope we were disappointed.

In these operations many thousand trees, large and small, have been cut down and a good many logs removed, and islands denuded of the small growth which covered them, in order that they might not obstruct the passage of boats during the high-water stage. About half of the available balance has been expended in this work, and the remainder will probably be sufficient to extend the same improvement as far as Barr's Ferry, fifty-five miles above Aberdeen and thirty miles above Cotton-Gin Port, to which latter point only, it was supposed, the available funds would enable us to go.

Since the close of the fiscal year these operations have been resumed, and by the close of the month of October the funds will be exhausted.

The estimates for the improvement of this river, as given in the reports referred to in the earlier pages of this report, are as follows:

For the improvement of the Tombigbee River from Columbus to the mouth.....	\$21,500 00	
Columbus to Fulton.....	35,000 00	
	56,500 00	
Appropriated act of June 10, 1872.....	10,000 00	
	46,500 000	
Out of the appropriation of.....	\$10,000 000	
There have been expended during the year ending June 30, 1873.....	\$5,332 95	
June 30, 1874.....	2,350 77	7,683,72
Unexpended balance.....		2,316 28

The whole unappropriated balance of \$46,500 could be profitably expended in this improvement during the next year.

The region benefited by this improvement would be Western Alabama and Eastern Mississippi. The nearest port of entry is believed to be Mobile, Alabama.

The amount of revenue received there is unknown to me.

Financial statement.

Amount in hands of officer and subject to his check.....	\$4,667 05
Amount expended during the fiscal year ending June 30, 1874.....	2,350 77
Amount available July 1, 1874.....	2,316 28
Amount required for the fiscal year ending June 30, 1876.....	46,500 00

P 4.

OOSTENAULA AND COOSAWATTEE RIVERS, GEORGIA.

Report of Captain L. Cooper Overman, Corps of Engineers.

UNITED STATES ENGINEER OFFICE,
Nashville, Tenn., March 19, 1874.

GENERAL: In compliance with telegraphic instructions, dated Washington, D. C., March 2, 1874, and letter dated Office of the Chief of Engineers, Washington, D. C., March 2, 1874, I have the honor to submit the following brief report and "estimate for the improvement of the Oostenaule River, Georgia, between Resaca and Carter's Mill."

The examination was commenced on the morning of the 13th instant,

and completed by the evening of the 14th instant. The Hon. P. M. B. Young accompanied me for a part of the time. The trip from Resaca to Carter's mill and back, for the examination of the river, was made on the steamer Mary Carter, built at Resaca, Ga., and intended to trade between Rome, Ga., and Carter's mill. This steamer, a stern-wheeler, is 111 feet long, 18 feet wide, 3 feet depth of hull, draws 10 inches light when under way, and from 24 inches to 30 inches when loaded. The cylinders of her engines are 10 inches in diameter and 30-inch stroke. The stage of water at the time of the examination, according to the testimony of those living on or near it, was from 24 inches to 30 inches above low-water.

At this stage the steamer employed had no difficulty, from want of sufficient depth of water, in passing over the whole length of river in question, as but one shoal was found with less than 33 inches of water upon it, and that only for a short distance.

Four miles above Resaca, by river, the Conasauga and Coosawatee Rivers unite, and from their junction to Rome, Ga., the stream is called the Oostenaula. Carter's Mill, the point mentioned as the end of the survey ordered, is on the Coosawatee River, near the foot of the "Chatua Mountains," through which the river breaks from the north-east. The distance from Resaca to "Carter's Mill" landing, by river, is estimated at 45 miles.

The river from Resaca to the junction of the Coosawatee is about seventy yards wide, with bluff banks and plenty of water at ordinary stages; from the junction to "Carter's Mill," the Coosawatee varies in width from sixty yards to forty yards. The banks are generally steep, frequently rising into high, rocky bluffs. The stream, except at the shoals, is from 5 to 10 feet deep at all seasons. The shoals are scattered along the 45 miles in question, and vary in length from a few yards to one-half a mile. The low-water season lasts ordinarily from June till November, but during the remaining months of the year the river is as high or higher than it was when this examination was made.

The navigation is at present obstructed even at ordinary stages in many places by sunken logs, trees, and "snags;" by "overhanging trees," which prevent a boat from keeping in the best water, and interfere with her management at short turns; by various "fish-traps," erected by individuals under the laws of the State of Georgia, which laws permit the same, provided an opening of 40 feet in width is allowed for the passage of boats; by the remains of two or three old mill-dams, which have only been partly removed, and by detached masses of rock lying in the channel, and especially dangerous in the short turns of the stream.

The navigation during the low-water season is still further obstructed by a number of gravel-bars and two or three rock-bars, or reefs.

APPROXIMATE ESTIMATE TO IMPROVE.

1st. To secure good navigation for boats drawing from 24 inches to 36 inches during seven months, (November to June;) cost of suitable derrick-boat, with quarters for men and blacksmith-shop on board.....	\$1,000 00
Services of two foremen, at \$3 per day, including rations for ninety days.	540 00
Services of twenty men, at \$1.50 per day, including rations for ninety days.....	2,700 00
Tools, materials, &c.....	350 00
Contingencies, 15 per cent.....	690 00
Total for seven months.....	5,290 00

2d. To secure good navigation during eight months, (October to June,) for boat drawing from 24 inches to 28 inches, would require 50 per cent. additional work and the improvement of four or five of the worst shoals.	
Approximate estimate for seven months.....	\$5,290 00
Adding 50 per cent. for additional work	2,645 00
Excavation of eight hundred cubic yards of gravel, at \$2 per yard	1,600 00
Excavation of two hundred cubic yards of rock, at \$4 per cubic yard.....	800 00
Total for eight months.....	10,335 00
3d. To secure good navigation for boats drawing 24 inches during nine months (October to July) would require the same amount of work as for eight months, with the improvement of six additional shoals. Approximate estimate for eight months	
Excavation of twelve hundred cubic yards of gravel, at \$2.....	\$10,335 00
Excavation of five hundred cubic yards of rock, at \$4	2,400 00
	2,000 00
	14,735 00
Contingencies, 10 per cent	1,473 50
Total for nine months	16 208 50

For a longer period than nine months the cost to improve would increase in a degree far beyond the advantage to be gained or the amount of trade benefited. No estimate is therefore made for a longer period than nine months.

Very respectfully, your obedient servant,

L. COOPER OVERMAN,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

APPENDIX Q.

REPORTS UPON BRIDGING NAVIGABLE WATERS OF THE UNITED STATES.

Q. 1.

BRIDGE ACROSS THE GENESEE RIVER, NEW YORK.

Letter of the Chief of Engineers.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 4, 1873.

SIR: Congress by an act approved March 3, 1873, (vol. 17, Statutes at Large, page 610,) authorized the Lake Ontario Shore Railroad Company to construct a draw-bridge across the Genesee River, in Munroe County, New York, and required that the structure shall be located and built under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe, &c.

The president of the company submitted drawings showing location and plan of the bridge, and also certain papers and petitions in relation thereto. These were referred to a board of engineer officers, instructed to assemble at Charlotte, N. Y., the site of the bridge, and, after a careful examination, to prepare such regulations as are necessary for the security of the navigation of the river, and report whether a bridge constructed at the location selected and according to the plan proposed will conform to these regulations.

The report of the board is herewith respectfully submitted. They recommend that the location of the bridge be approved, and that the draw-openings proposed by the company, viz, 70 and 71 feet, be accepted.

In regard to the height of the bridge above surface of the river, the board expresses the opinion "that the under-surface of the bridge should not be less than 13 feet above high-water mark." This would require the plan proposed by the president of the company, in his letter of July 25, to be raised $11\frac{1}{2}$ feet.

The board recommend certain regulations for the working of the bridge: First, that in all cases the navigation interests shall have the precedence in passing the bridge; and second, that during the season of navigation the company be required to keep such lights at the draw as may be prescribed by the Light-House Board.

¶ These appear to be matters of regulation, belonging rather to the local or State authorities, and not contemplated in the act of Congress as coming under the supervision of the War Department.

The views and recommendations of the board, with the above exception, are concurred in by me, and if they meet your approval, it is recommended that I be authorized to so inform the president of the railroad company.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General, and Chief of Engineers.

Hon. W. W. BELKNAP,
Secretary of War.

[Indorsement.]

The Secretary of War approves the recommendations of the Chief of Engineers.

H. T. CROSBY,
Chief Clerk.

OCTOBER 8, 1873.

Report of Board of Engineers.

CHARLOTTE, N. Y., August 26, 1873.

GENERAL: The Board of Engineer Officers constituted by Paragraph 1, Special Orders No. 103, dated Headquarters Corps of Engineers, Washington, D. C., August 15, 1873, convened at Charlotte, N. Y., August 26, 1873, in obedience to that order, all the members being present.

The board proceeded to examine and deliberate upon the several maps and papers brought to their attention, and bearing upon the question of the location and plan of the bridge proposed to be built across the Genesee River, in Monroe County, New York, by the Lake Ontario Shore Railroad Company. The resident engineer of that company laid before the board all data necessary to enable the members to form their opinions upon the matter in question. The Board also gave careful attention to the opinions expressed by dock-owners, masters of tugs, and prominent citizens of the village of Charlotte. Full opportunity was given, and a free expression of public opinion was invited as to the location and plan of the proposed bridge, resulting in, with one exception, a general expression of approval of the railroad company's project without alteration in any manner.

The board, after mature deliberation and a thorough discussion of the subject in all its bearings, came to the following conclusions, which they respectfully present as their

REPORT.

In discussing the wants of the harbor at Charlotte, N. Y., and the necessary qualifications of a bridge to be built across the Genesee River, which forms this harbor, the board feel that it would be very shortsighted to limit themselves to the present wants of the village at the mouth of the Genesee. The harbor at Charlotte has been recently made one of the best on Lake Ontario, and being only seven miles from the large city of Rochester, of which it is the port and with which it is connected by a branch of the New York Central Railroad, it is reasonable to assume that its commerce will steadily grow with the general growth of the country, if it does not do so at a faster rate.

As all bridges across navigable waters are obstructions, it is manifest that the only safe method is to so regulate them that they shall present the least possible hinderance to free navigation, and be adapted as far as possible to the greatest probable development of commerce, provided that in so doing no excessive burden is thereby imposed upon those building them.

Acting on these general views the board come to the following conclusions:

LOCATION OF THE BRIDGE.

The Board approve of the location, believing that in the course of time a bridge at or near the point selected will become a necessity, and that there is no good reason for refusing the privilege to the railroad company that in all probability would be granted at some future time to them or other parties.

It has been asserted that in heavy storms vessels need a free entrance to a point above the site selected for the bridge, but this was denied by the master of one of the tugs belonging to the harbor, and the Board have every reason to consider his statements correct.

WIDTH OF DRAW-SPAN.

The act of legislature of the State of New York, the conditions of which are accepted in the act of Congress legalizing the proposed bridge, requires a draw with two clear openings of 60 feet each. The railroad company propose giving one opening of 70 feet and the other of 71 feet. These openings we consider sufficient and recommend that they be accepted. At Chicago the Rush-street bridge gives 78 feet, the Clark and State street bridges 67 feet, and the Wells-street bridge 62 feet. The Ohio-street bridge at Buffalo gives 67 feet. The proposed openings for the Charlotte bridge are, therefore, in excess of all excepting the Rush-street bridge at Chicago.

HEIGHT ABOVE WATER OF THE UNDER-SURFACE OF THE BRIDGE.

The board believe that in order to reduce to the minimum the obstruction caused by this bridge it is essential that it should have a height sufficient to permit all tugs to pass under freely, so that the draw need only be swung when masted vessels and steamers require passage.

If a large city should ever arise at this point a bridge too low for the passage of tugs would be an intolerable nuisance. Knowing how very difficult it has always proved to change the order of affairs once established, when such change is opposed by a wealthy and influential cor-

poration, the board believe that the only way to secure the rights of navigators is to insist upon the proper order of affairs from the beginning. We, therefore, are of the opinion that the under surface of the bridge should not be less than 13 feet above high-water mark. The top of the pilot-house of a first-class tug, with chimney lowered, is 12 feet above water, and 1 foot is needed for clearance.

At Buffalo the Ohio-street bridge is 12 feet above high-water and 14 feet above low-water. The new Michigan-street bridge at the same city is to be nearly 14 feet above high-water, and nearly 16 feet above low-water, thus indicating that experience has shown the need of a greater height than was given to the Ohio-street bridge. The height we have selected is the mean of the two, and we believe it to be the lowest admissible. The effect of this change would be to require the company to raise their bridge $11\frac{1}{2}$ feet higher than indicated in the elevation furnished us with our instructions. We have carefully examined the profile of that portion of the Lake Ontario Shore Railroad which crosses the Genesee Valley, and are satisfied that there is no material difficulty in making the change recommended. The new level of the bridge can be reached by a grade not exceeding 52.8 feet to the mile, commencing 1,125 feet east of the bridge. On the west side by means of a down grade of 39.6 feet to the mile, the level of the furnace-track can be reached at its crossing. This level may then be continued westwardly until the railroad company's up-grade is reached. The practical effect on the main line will be simply to change a portion of up-grade from the west side of the valley and put it on the east side, and a portion of the down-grade from the east side to the west side. No change whatever, either in construction or in use, would be made in the siding leading to the wharves north of the proposed slips, and in the other siding the difference would simply be that westwardly-bound trains made up at the wharves would have to back out a few hundred feet further before crossing the bridge than they would if the proposed change were not made. On the west side the railroad would cross the furnace-track at a level instead of 4 feet below, as now graded, thus avoiding an inconvenience. The New York Central track could pass under the raised track without difficulty.

The board are of the opinion that there are no engineering difficulties whatever in the way of the proposed changes, and that the question is simply one of money. We estimate the cost of the changes recommended at not to exceed \$20,000. The temporary use of trestle-work would much diminish this estimate.

In view of the great expense of building a long line of railroad, the sum above mentioned is insignificant, and in view of the great injury that may be done to the harbor if the changes recommended are not made, even at this cost, it does not seem unreasonable to demand that the railroad company shall make this necessary expenditure, in view of the privilege granted them of crossing Genesee River Harbor near its mouth.

REGULATIONS CONCERNING USE OF BRIDGE.

The board are of opinion that the right of way properly belongs to navigation, and that the draw should always stand open when not in actual use, and that should a vessel desire to pass when a train is about to cross, the train should wait until the vessel has gone by. They would also recommend that the company be required to keep such lights at the draw as may be prescribed by the Light-House Board.

Respectfully submitting these conclusions, and forwarding with this our report, the maps and papers specified in the accompanying schedule,

We have the honor to be, very respectfully,

WM. E. MERRILL,
Major of Engineers.

JOHN M. WILSON,
Major of Engineers, U. S. A.

F. HARWOOD,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

Q 2.

BRIDGING THE CHANNEL BETWEEN LAKES HURON AND ERIE.

Report of the Board of Engineers.

DETROIT, MICH., December 24, 1873.

GENERAL: The Board of Engineers appointed by Paragraph 3, Special Order 61, dated War Department, Adjutant-General's Office, March 18, 1873, to inquire into and report upon the practicability of bridging, consistently with the interests of navigation, the channel between Lake Huron and Lake Erie, &c., in accordance with section 3 of act of Congress approved March 3, 1873, and convened by your order of March 26, has the honor to submit the following report:

Pursuant to the above orders the board met at Detroit, Mich., on the 12th of May, and representatives of the opposing interests presented their several opinions, as follows:

Railroads.—Michigan Central Railroad and Canada Southern Railway: A. B. Maynard, esq., United States district attorney and attorney for these roads.

Michigan Central Railroad: James F. Joy, esq., president.

Canada Southern Railway: George Goss, esq., managing director, and E. W. Meddaugh, esq., attorney.

Navigation.—Captain E. B. Ward, Captain Eber Ward, E. G. Merrick, esq., G. W. Bissell, esq., Robert J. Hackett, esq., and several others.

The railroad companies desired to bridge the strait, while those in the interest of navigation protested against it, and for three days the matter was fully and openly discussed, and opinions mutually interchanged between the several parties and the members of the board.

It appeared that much preliminary information would be required before the subject could be properly treated, and the board accordingly adjourned on the 17th, subject to the call of the senior member.

In the interim observations were made on the velocity and direction of the currents, the nature of the river-bottom, sub-strata, &c.

A continuous record of passing vessels was kept, the methods of navigation now in use were investigated, and commercial statistics, for several past years, compiled from various sources.

Surveys, examinations, and estimates were also obtained from the railroad companies, and statements, in writing, received from both parties upon many points bearing on the question.

On the 14th of November the board re-assembled, and after digesting the accumulated information the final statements of the parties above-mentioned were heard.

Three days were then occupied in deliberation, and the board finally adjourned on the 19th of November.

Section 3 of act of Congress making appropriations for repairs, preservation, and completion of certain public works on rivers and harbors, approved March 3, 1873, reads as follows:

That the Secretary of War is hereby authorized and required to detail from the Engineer Corps one or more engineers, whose duty it shall be to inquire into and report upon the practicability of bridging, consistently with the interests of navigation, the channel between Lake Huron and Lake Erie at such points as may be needed for the passing of railroad-trains across said channel; and, further, to inquire into the number and character of the vessels navigating said channel, and the number of trips made by each; and, if said bridging be practicable, to report what extent of span, or spans, and elevation above the water, will be required in the construction of such bridge or bridges, so as not seriously to injure the navigation of said channel.

DESCRIPTION OF WATER-WAY BETWEEN LAKES HURON AND ERIE.

Of the great railroad thoroughfares which traverse the continent, from east to west, one of the most important routes lies across the peninsula of Upper Canada.

The valley of the Hudson River, by piercing the range of the Alleghany Mountains, continuous for nearly a thousand miles, affords to this route facilities for reaching the sea-coast not enjoyed by others, but the delay and expense of crossing the channel under consideration detracts to some extent from the superiority which its railroads possess by reason of their low grades.

The strait or channel through which the waters of the upper lakes discharge themselves in Lake Erie is designated at its origin as the Saint Clair River.

On leaving Lake Huron, the opposite banks are not more than 800 feet distant, but the passage soon assumes its ordinary breadth, which may be estimated at 700 yards. Twenty-seven miles below Lake Huron it separates into a delta, twenty miles wide, and enters Lake Saint Clair, a shallow sheet of water, through no less than eight independent outlets, one of which has been artificially deepened and protected by wooden cribs.

From the head of the delta to this canal the water-way measures thirteen miles, and the distance across the lake is about seventeen miles. Here the waters are again contracted, and, under the name of the Detroit River, flow with a gentle current past the city of the same name, which is located on its right bank, seven miles from its origin. Near its upper and lower course, two or three small islands divide the channel; but throughout its length the general width of the main channel may be taken as 2,000 feet.

The total length of the navigable course of Detroit River is twenty-eight miles, and of the whole of the strait, from Lake Huron to Lake Erie, about 85 miles. Its general direction is 30° west of south, and the accompanying tables will show in further detail the dimensions and characteristics of those locations at which the railroad companies might bridge the stream, and of other important points in the channel.

It will thus appear that it affords throughout its whole extent the finest facilities for the passage of vessels.

The average width of the channel of the Saint Clair River, which would be navigable for boats of 16 feet draught, may be computed at 2,000 feet, with an average depth of 36 feet, and that of the Detroit River at about the same width, but with less depth in its lower course.

The only points at which any serious difficulties to navigation exist

are at the Lime-Kilns, below Stony Island, and in the old channel at Saint Clair Flats. The former lies partly in Canadian waters, and though vessels sometimes strike in passing, yet the difficulty might be obviated at small expense. But at the latter channel the depth is about 14 feet, and vessels of that draught are confined in their course to a passage of about 150 feet width.

So narrow a water-way was an injury to navigation; and the United States Government has been constructing, at the expense of half a million dollars, an artificial channel, or canal, which gives a clear opening of 300 feet for vessels of 13 feet draught, and this depth is now being increased to 16 feet.

TABLE No. I.—*Showing the dimensions of Detroit and Saint Clair Rivers at important points the figures marked thus * being approximate.*

Place.	Distance of point from Lake Huron, measured along channel.	Width of river.	Width of channel.	Greatest depth.	Average depth.	Height of banks.	Nature of bottom.	Maximum distance to bed-rock.	Average distance to bed-rock.	Rapidity of current in channel in miles per hour.	Rapidity in ordinary weather, (maximum.)
Fort Gratiot G. T. Railway crossing.....	4	800	780	48	30	15	Rock..	48	.....	*5	*6
Saint Clair projected crossing of branch of C. S. Railway.....	144	2,820	2,600	42	30	20	Clay ..	.....	.....	.....	.....
Saint Clair Flats Canal.....	40	.....	300	16	14	Artificial	Clay ..	.....	.....	.....	.....
Site of tunnel.....	62½	2,800	2,700	45	40	25	Clay ..	110	105	2½	2½
Detroit M. C. Railway depot.....	63½	2,900	2,750	48	40	25	Clay ..	85	80	2½	3
Stony Island.....	78	3,500	2,000	27	14	25	Rock..	27	14	2½	5
Lime-Kilns.....	79	3,000	600	18	9	.....	Rock..	18	9	*3½	*3
Mouth of Detroit River ..	85	30,000	.....	27	15	.....	Mud ..	.....	.....	1	.....

The channel is usually free from fogs, except occasionally in the spring. The prevailing winds are from the southwest, though it frequently blows with violence from all points of the compass. It is scarcely affected by tides, and the annual changes in water-level rarely exceed two feet; but during the winter season it is much obstructed by ice, and at some points is completely frozen over for several weeks.

It is usually in the month of December that the shallow waters of Lake St. Clair and the west end of Lake Erie begin to freeze over, and the floating ice which soon appears in the rivers is so dammed up by this impediment that the blockade gradually extends to their upper courses, and it has been stated by the pilots and ferrymen that, although the floating cakes range in thickness only from eight to sixteen inches, the accumulated mass often covers considerable areas to the depth of five or six feet in the severest weather.

But at the head of St. Clair River the influx of ice is stopped by the blockade at the foot of Lake Huron, and the rapid current keeps the passage quite open in all seasons of the year.

Of the value to the country of the water-way between Lakes Huron and Erie, now described, no estimate can be made. It is a part of a magnificent channel for commerce, stretching uninterruptedly from Chicago to Buffalo, a distance of eight hundred and eighty-eight miles; or, if we include the ship-canal in connection with it, from Ogdensburg to Du Luth, a distance of one thousand two hundred and twenty-eight miles; and to its existence are due, in a large degree, the growth and wealth of the great Northwest.

AMOUNT AND CHARACTER OF NAVIGATION ON THIS WATER-WAY.

If the tonnage of entries and clearances reported by the several customs districts be taken to measure the amount of navigation, it will appear from the Tables II and III, below, that that of the northern lakes is 40 per cent. of the total coastwise and foreign trade of the country; that one-sixth of the vessels in the country are engaged in it; and that in the year more trips are made on these lakes than in all the rest of the country. To maintain and foster this commerce over a million dollars are annually appropriated by the General Government for the improvement of its harbors and water-ways.

The strait just described is the key to all these lakes; and it will be seen below, from Tables III and IV, that during the summer, if July be taken as an average month, more than one-half of the lake commerce, and nearly one-third of all in the United States, passes through it; and during these months about three times as many passing vessels have been observed here during the last season as the sum total of the entrances and clearances of the port of New York for the same time in 1872.

During the eight months of navigation, usually from April to December, 27,000 vessels annually pass this channel, and of this number more than 20,000 carry masts varying in height from 80 to 160 feet.

Most of the sailing-vessels are towed in their passage by large and powerful tugs, taking from one to ten vessels at a time, and the largest tows sometimes exceed three-fourths of a mile in length; but the average number would be between two and three vessels to each tow, making the total number of separate passages over 15,000 per year.

The details of this method of navigation are given in Table VI; while Table VII shows the relative number of the different classes of vessels as well as the average and maximum dimensions of each class, and No. X the proportion of the different kinds of cargo for the year 1872; this being taken from the statement of Messrs. Bissell and Hackett, submitted herewith.

In all these tables the figures marked thus * are taken from the report of the Chief of the Bureau of Statistics for 1872.

TABLE No. II.—*Showing the number of United States merchant vessels and amount of tonnage, geographically classified.*

	Number.	Tons.
Atlantic and Gulf.....	*22, 574	*3, 094, 903. 33
Northern lakes.....	*5, 337	*724, 493. 51
Pacific.....	*1, 127	*180, 348. 44
Western rivers.....	*2, 076	*448, 001. 36
Total.....	*31, 114	*4, 447, 746. 64

TABLE No. III.—*For comparing the number of trips coastwise or to foreign countries made by all vessels, of whatever nationality, throughout the country, with those which pass through St. Clair Flats in the same length of time.*

	Time.	Number of trips.	Tonnage.
United States.....	July, 1872	*129, 364	*49, 779, 295
	July, 1872	*10, 966	*5, 632, 297
Northern lakes.....	July, 1872	*69, 101	*18, 674, 263
	July, 1872	*11, 102	*2, 264, 574
Passed St. Clair.....	July, 1873	127, 109	3, 116, 570
	July, 1873	15, 107	\$1, 600, 000

† From Table No. VI.

‡ From Table No. X.

§ Approximated by several independent methods.

NOTE.—The figures for the United States and northern lakes are obtained by adding together the number *entered* and *cleared* in the *foreign* and *cleared* in the coastwise trade.

Number of vessels entered and cleared at port of New York, 1872, foreign and coastwise: Number, 18,840; tonnage, 11,803,958.

TABLE No. IV.—Showing the ratio of the commerce under consideration to that of several cities.

	NUMBER OF VESSELS.					
	July, 1872.			October, 1872.		
	Entered.	Cleared.	Total.	Entered.	Cleared.	Total.
New York	*749	*851	*1,600	*816	*917	*1,733
Passed St. Clair Flats		1873. { 5,107				4,113
Fort Wayne		{ 4,348				
Stony Island		{ 3,544				
	TONNAGE.					
New York	*496,000	*523,000	*1,019,000	*534,000	*573,000	*1,107,000
Baltimore	*116,000	*146,000	*262,000	*129,000	*163,000	*292,000
Boston	*200,000	*201,000	*401,000	*172,000	*184,000	*356,000
Chicago	*484,000	*487,000	*971,000	*441,000	*438,000	*879,000
Milwaukee	*379,000	*385,000	*764,000	*344,000	*352,000	*696,000
St. Clair Flats, approximately ...	Up. 900,000	Down. 900,000	1,800,000	Up. 700,000	Down. 700,000	1,400,000

TABLE No. V.—Showing the relative importance in tonnage in summer months of lake commerce and other commerce, July, 1872.

	Foreign.		Coastwise.		Entered and cleared foreign and cleared coastwise.	Total.
	Entered.	Cleared.	Entered.	Cleared.		
Atlantic	*609,000	*634,000	*1,159,000	*1,030,000	2,273,000	3,432,000
Gulf	*19,000	*30,000	*112,000	*98,000	147,000	259,000
Pacific	*67,000	*53,000	*56,000	*40,000	160,000	216,000
Lakes	*388,000	*390,000	*2,159,000	*2,185,000	2,963,000	5,122,000
Interior	*9,000	*12,000	*63,000	*64,000	85,000	148,000
Total United States...	*1,092,000	*1,119,000	*3,549,000	*3,417,000	5,628,000	9,177,000

TABLE No. VI.—Showing the number of vessels that passed different points of the channel in question.

	Stony Island, 1873.	Fort Wayne, 1873.	St. Clair Flats, 1873.	St. Clair Flats, (partial count,) 1872.	St. Clair Flats, (partial count,) 1871.
January					
February					
March					
April	649			314	
May	2,153			1,704	
June	3,010	3,866		1,941	
July	3,544	4,348	5,107	2,612	2,338
August	3,702	4,562	4,186	2,860	1,838
September			4,376	2,460	1,807
October			4,113	2,438	1,663
November			*1,721	1,655	1,391
December				102	66
Total			19,503	15,486	

* To November 25.

If we take the whole number of vessels which passed the flats in 1872, and divide by the number from July 1 to November 25, it gives $\frac{39}{100}$ as the ratio to be added to those observed in 1873 to express the total for this season, which may therefore be computed at 27,109. The number counted by the light-keeper at Port Huron for the previous year is given at 26,381 for the day-time only, to which he adds 25 per cent. for those passing at night.

The first column is from observers in employ of Canada Southern Railway.

The second and third columns are from those in the employ of the Board of Engineers, and are considered reliable, but may be somewhat too small, since some vessels passing at night may not have been seen.

The fourth and fifth columns are from count by the custodian of the St. Clair Flats Ship-Canal, who counted only the larger class of vessels passing between daylight and 10 p. m.

TABLE NO. VII.—Showing the number of vessels of each class which passed St. Clair Flats in 1873, taken from actual count, from July 1 to November 25, with 39 per cent. added in second line, as in Table VI, to represent the total number for the year.

	Side-wheel steamers.	Propellers.	Steam-barges.	Tugs.	Barks.	Brigs.	Two-mast.	Three-mast.	Barges.	Rafts.
July 1 to November 25.....	300	2,086	2,496	3,170	550	153	3,567	3,600	3,047	25
April 1 to December 1.....	417	2,898	3,470	4,406	765	211	4,958	5,004	4,236	42

DIMENSIONS OF THE ABOVE CLASSES GIVEN BY MR. KIRBY, SHIP-BUILDER.

	75	42	40	26	40*					
Maximum beam.....	55	30	32	22	30					125
Average beam.....	280	275	250	150	247					75
Maximum length.....	200	200	200	130	190					2,000
Average length.....	10½	14½	14½	13½	14½					2,000
Maximum draught.....	8½	12½	12	12½	12					2
Average draught.....	35	40	40	30	30					
Maximum height pilot-house.....	25	30	30	20						
Average height pilot-house.....										
Maximum height smoke-stack, above water.....	60	60	60	50						
Average height smoke-stack.....	50	50	50	40						
Maximum masts.....		120	120		165					
Average masts.....		110	110		140					
Maximum tonnage.....	1,600	1,502	1,406	247	1,002					
Average tonnage.....	800	750	800	220	700					
Maximum horse-power.....	1,200	800	800	500						
Average horse-power.....	600	600	350	350						

* This column indicates sailing-vessels of all classes.

Other papers say that rafts average 800,000 feet, b. m., to 1,000,000 feet, b. m.; and measures 2,600 feet × 50 feet, and 2,000 feet × 50 feet; or 1,000 feet × 100 feet, and 1,500 feet × 100 feet.

TABLE NO. VIII.—Showing the length of several tows, taken from actual observations made by John T. Cox, civil assistant.

	Total length.	Length per vessel towed.
	<i>Feet.</i>	<i>Feet.</i>
Tug and three vessels.....	1,300	400
Do.....	1,150	383
Tug and four barges.....	1,600	400
Tug and five vessels.....	1,950	390
Tug and four vessels.....	1,500	375

Average length per vessel, 389 feet.

Raft of saw-logs, 2,000 feet long.

TABLE No. IX.—*Showing for two weeks (selected at random from the records of the Board) the number of tows of different lengths that passed Fort Wayne, and the average time of passing.*

	Number of each class that passed week ending June 7, 1873.	Number of each class that passed week ending July 12, 1873.	Average time of each class in passing a given point, taken for three weeks in July, 1873.
			m. s.
Tug and one vessel.....	58	49	28
Tug and two vessels.....	30	40	1 01
Tug and three vessels.....	35	34	1 48
Tug and four vessels.....	16	25	2 01
Tug and five vessels.....	6	17	2 35
Tug and six vessels.....	2	1	4 00
Tug and seven vessels.....			5 00
Tug and eight vessels.....	1	1	6 30
Tug and nine vessels.....		1	8 00
			Tows going down.

TABLE No. X.—*Taken from statement by Messrs. Bissell & Hackett, to show the number of tons, &c., of different kinds of freight which passed Detroit in 1872.*

Freight.	Quantity.	Weight.
		Tons.
Lumber.....feet..	971, 977, 349	1, 943, 954
Coal.....		1, 109, 196
Grain.....bushels..	75, 146, 567	2, 028, 857
Flour.....barrels..	800, 034	86, 403
Iron, ore and pig.....		985, 621
Salt.....barrels..	616, 009	92, 400
Staves.....		106, 693
Wood.....		201, 289
Sand.....		39, 431
General merchandise.....		876, 789
Stone.....		132, 748
Entered and cleared at Detroit in small vessels, &c., vessels less than 150 tons.....		328, 717
In large vessels, &c., vessels over 150 tons.....		1, 182, 472
Total for 1872.....		9, 116, 570

TABLE No. XI.—*Showing the number of sail and steam vessels that passed Fort Wayne in tows or single for three months, and the approximate numbers of each kind for the whole season of navigation.*

1873.	Steam.		Sail.		Gross total, 3 months.
	Single.	Towing.	Single.	Towed.	
May 24 to July 28.....	3, 675	1, 954	1, 498	4, 581	11, 708
Approximate for year.....	8, 500	4, 500	3, 500	10, 500	27, 000
	8, 500				
	4, 500				
	3, 500				
No. of single passages.....	16, 500				
Average number of vessels to one tug.....	10, 500				
	4, 500-2½				

From the preceding statements an idea of the magnitude and character of the commerce passing through the channel connecting Lakes Huron and Erie may be formed.

RAILWAY-CROSSINGS OF SAID WATER-WAY EITHER EXISTING OR PROPOSED.

The points at which railroads are interrupted by the water-way are Sarnia, St. Clair, Detroit, and Stony Island. At Sarnia the Grand Trunk Railway crosses the St. Clair River at a point where the current is so rapid that the passage of ferry-boats is never obstructed by ice. The Grand Trunk Company apparently has no desire for a bridge at Sarnia, and has not furnished any statistics to the board in reference to freight crossed there. It seems probable that the crossing of freight by ferry is more economical than by any admissible bridge.

At St. Clair a branch of the Canada Southern strikes the St. Clair River, but the representative of the road stated that no bridge was desired. It is not known that any commercial freight has been crossed at this point.

At Detroit the freight and passengers of the Michigan Central Railroad are ferried across the river to the Great Western Railway at Windsor by the latter company.

From Table XIII it appears that in the year ending April 15, 1873, there were crossed by three ferry-boats 838,310 tons of freight and 218,858 passengers. During the season of navigation there is no difficulty in transferring freight and passengers by ferry, and the method is probably cheaper than by bridge. Indeed, the president of the Michigan Central Railroad stated to the board that if it were not for the ice a bridge would not be thought of; but, during ordinary winters, the ice has been an obstacle which, in the severe winter of 1872-73, became very serious, and, aided by lack of rolling-stock on the Great Western Railway, caused a serious blockade of freight at the Detroit River. It is probable that, with ferry-boats better adapted to breaking down the ice, less trouble would be experienced; and it is stated that the Great Western Railway is now adding such a boat.

Tables XII, XIV, XV, XVI give details as to railroad connections as to these ferry-boats and their rates of crossing. It will be seen that the average time of crossing in January, 1873, was more than double that in the summer months, and this difference was doubtless mainly due to ice.

TABLE No. XII.—Showing the connections of railroads on either side the strait.

Name of railroad on Canada side.	Point at which it reaches the channel in question.	Part of the channel crossed.	Distance in miles of the point from Lake Huron.	Eastern terminations.	Names of railroad on American side.	Point at which it reaches the channel.	Western terminations.
Great Western Railway of Canada.	Windsor....	Detroit River...	63	Suspension Bridge, Buffalo, Toronto.	Michigan Central branch of Michigan Southern, Detroit and Milwaukee.	Detroit.....	Chicago, (southern termination,) Toledo, Grand Haven.
Small branch of Great Western Railway.	Sarnia.....	St. Clair River..	24	Buffalo, Quebec, Portland, Me. Buffalo.....	Port Huron and Lake Michigan...	Port Huron.....	Grand Haven.
Grand Trunk Railway of Canada.	Huron.....	St. Clair River..	4	Buffalo, Quebec, Portland, Me. Buffalo.....	Grand Trunk Railway.....	Gratiot.....	Detroit.
Canada Southern Railway.	Above Amherstburg..	Detroit River...	78	Buffalo.....	Chicago and Canada Southern....	Stony Island, thence to Trenton.	Not completed.
Branch of Canada Southern	Courtright..	St. Clair River..	144	Buffalo.....	Michigan, Midland, and Canada, (projected.)	Below St. Clair City.	Not completed.

TABLE No. XIII.—Statement, furnished by the Great Western Railway Company of Canada, of the cost of transferring freight and passengers at Detroit.—Two years, April 16, 1871, to April 15, 1873.

Time.	Freight.								
	Steamer Great Western.			Steamer Transit.		Interest on cost, depreciation, and insurance.	Total.	Tonnage ferried.	Cost per ton.
	Wages of crew.	Fuel and repairs.	Wages of crew.	Fuel and repairs.					
April 16, 1871, to December 15, 1872	\$8,603	\$18,732			\$24,882	\$52,218	475,294	\$10 98	
December 16, 1871, to April 15, 1872	4,463	9,758			12,441	26,663	241,577	11 03	
April 15, 1872, to December 15, 1872	9,137	21,910	\$3,714	\$5,956	31,096	71,814	556,882	12 90	
December 16, 1872, to April 15, 1873	5,054	14,834	4,587	11,000	18,654	54,132	291,458	19 23	
Total.....	27,258	65,236	8,301	16,957	87,074	204,828	.	.	

Time.	PASSENGERS.					
	Steamer Union.		Interest on cost depreciation, and insurance.	Total.	Passengers ferried.	Cost per passenger.
	Wages of crew.	Fuel and repairs.				
April 16, 1871, to December 15, 1871.....	\$5,138	\$12,412	\$17,357	\$34,908	\$133,646	<i>Cents.</i> 26.12
December 16, 1871, to April 15, 1872.....	2,792	7,188	86,78	18,660	49,476	31.71
April 16, 1872, to December 15, 1872.....	5,536	19,611	17,357	42,505	166,970	25.45
December 16, 1872, to April 15, 1873.....	3,171	20,623	8,678	32,473	51,888	32.38
Totals	16,638	59,836	52,072	128,548	401,980	

TABLE No. XIV.—Showing the dimensions, &c., of the ferry-boats belonging to the Great Western Railway Company, taken from Document No. 9, furnished by that company.

Name.	Dimensions.			Tonnage.		Cost in gold.	Capacity.
	Length.	Beam.	Depth of hold.	Gross.	Registered.		
Union, (paddle).....	<i>Ft.</i> 163	<i>Ft. in.</i> 33 6	<i>Ft.</i> 11	1,190	999	\$120,424	
Great Western, (iron paddle)...	220	40 2	.....	1,252	712	197,863	14 loaded cars.
Transit, (propeller—2 wheels) ..	168	39 10	.....	759	327	93,000	10 loaded cars.

Saginaw, small steamer. Dimensions not given.
 It is said that the Grand Trunk ferry-boat International carries 21 cars. The dimensions of the Canada Southern steamer have not been furnished.

TABLE No. XV.—Showing work and time of ferry-boats Great Western and Transit, taken from record 102, furnished by Great Western Railway Company.

Month.	GREAT WESTERN.			
	Average number of trips daily.	Average time per trip.		
		Time running.	Time at dock.	
			Loading and unloading.	Lying idle.
1872.				
September	28.5	<i>Minutes.</i> 16.60	<i>Minutes.</i> 26.00	<i>Minutes.</i> 7.93
October	24.2	17.89	25.2	12.43
November	24.8	19.43	28.5	9.01
December	18.5	30.65	30.0	17.19
1873.				
January	14.06	39.25	28.0	35.13
February	20.5	28.20	27.4	14.63
March	23.04	18.675	29.9	13.93
April	23.74	17.77	26.0	16.29
May	26.6	17.02	26.0	11.13
June	26.4	16.60	28.3	8.66
July	22.74	16.60	29.2	12.50
August	Laid up			

TABLE NO. XV.—*Showing work and time of ferry-boats Great Western and Transit, taken from record 102, &c.—Continued.*

Month.	TRANSIT.			
	Average number of trips daily.	Average time per trip.		
		Time running.	Time at dock.	
			Loading and unloading.	Lying idle.
1872.		Minutes.	Minutes.	Minutes.
September	13.20	19.85	18.0	71.24
October	21.26	19.45	18.0	30.28
November				
December	13.16	21.23	20.0	68.19
1873.				
January	14.55	31.74	20.0	47.23
February	21.28	22.08	20.0	25.59
March	22.03	19.00	20.0	26.37
April	21.50	16.23	18.0	32.75
May	25.55	14.90	18.0	23.46
June	18.97	15.00	18.0	42.91
July	37.96	15.50	18.0	4.43
August	36.66	16.00	18.0	5.28

TABLE NO. XVI.—*Showing the number of trips made by Great Western ferry-boat from dock to dock during the month of January, 1873, in 10, 20, 30, &c., minutes, compiled from log of steamer Great Western—the month of January, 1873, being said to be the worst on record.*

Minutes.	Trips.	Minutes.	Trips.	Minutes.	Trips.	Minutes.	Trips.
10	36	80	-----	150	7	230	-----
20	183	90	-----	160	-----	240	-----
30	107	100	6	170	1	250	-----
40	58	110	4	180	2	260	-----
50	35	120	6	200	-----	270	-----
60	-----	130	6	210	1	280	-----
70	-----	140	8	220	3	290	1

It will also be seen by the following extract from the annual report of June, 1873, by the president of the Michigan Central Railroad, that, in his opinion, the means of ferriage supplied by the Great Western Railway have been entirely inadequate to the business:

It (the Great Western) undertakes to do the ferry business at Detroit, but the means have been wholly inadequate. Even before the winter set in, during several months the cars could not be taken across as rapidly as was requisite, and for that period, all the time, large numbers of loaded cars, often as many as from seven hundred to one thousand, were waiting in our yards to be moved across. When winter came on—and it was the most severe by far ever known at Detroit—the difficulty was still greater; though, could the freight have crossed, it could not have been got over that road.

Although the last-named difficulty may be so far corrected as to relieve the railroad companies from embarrassment, yet the gross earnings of eight miles of railroad are expended in crossing during the summer season, and those of more than twelve in a winter of unusual severity. Moreover, the delay to passenger traffic is an important consideration; hence an association, representing \$100,000,000 capital, did not regard \$2,650,000 too great an outlay to secure, by means of a tunnel, with double track, an uninterrupted passage-way of a most permanent nature, capable of fulfilling the demands of an unlimited increase

of traffic, and neither subject to delay from the condition of the river nor from encountering the constant stream of navigation which has been described.

The accompanying papers of Mr. Chesborough, the engineer, and of Mr. McBean, the superintendent of the Detroit-River tunnel, will serve to give a correct idea of its history; and while the former explains the object of the plan he adopted, the latter dwells with bitterness upon the abandonment of the enterprise.

This tunnel, commenced in the winter of 1872, was to pass under the Detroit River, from Windsor to Detroit.

Its plans and sections, furnished by the Michigan Central Railroad, show the limestone bed-rock, at 110 feet below the river level, with the following formations immediately above: 1st, hard-pan, with bowlders, 10 feet in thickness on the Canada side and 22 feet on the American; 2d, forty feet of hard blue-clay, perfectly clear, on the American side, but with a vein of sand on the other, varying in thickness from a few inches to two feet, and lying one or two feet above the hard-pan; 3d, ten feet of laminated clay; and, 4th, the soft blue-clay of the river-bottom.

The work was begun by sinking two shafts, 3,275 feet apart, at Detroit and Windsor, respectively, and a small drift of 5 feet in the clear was started to explore the ground and to form a drain for the main work when completed. It appears from Mr. Chesborough's statement that the American drainage-tunnel, of 1,220 feet, was completed without embarrassment, but not without difficulty or delay, for its course lay not in the blue-clay, as they had supposed, but in the hard-pan, which had not been reached by their economical boring-apparatus. On the Canada side they were delayed from the same cause, and the veins of sand, above mentioned, occupied so much of their attention, that the railroad companies began to get impatient.

At the annual meeting of the stockholders of the Great Western Railway, at London, Ontario, April 7, 1873, the chairman says: "We now believe that, by making the proper application we shall be able to get the bridge over that river by a smaller expense than the tunnel, and get it more expeditiously done." And Mr. Chesborough says, after it had been abandoned: "While the construction of the Detroit tunnel, as a simple engineering problem, cannot seem otherwise than practicable to members of the profession, * * * * * the advisability of constructing it, as a judicious expenditure of money, is more doubtful." The growing hope that a bridge would be permitted was doubtless one motive for abandoning the tunnel.

At Stony Island the Canada Southern Railway crosses the river, where the total width of water-way on the line of the railway is 6,640 feet. Of that distance, by bridging, embankment, and piers, the railway has already taken possession, entirely without authority of the United States, of 3,280 feet, and, doubtless, in the future hopes to take possession of the remaining gap.

The line of this road, as prolonged, crosses the river at a short distance above one of the narrowest and worst places for heavy vessels in the river, known as "the Lime-kilns," where, during the past season, a large amount of damage has been done to navigation by heavily-laden vessels touching the rocky bottom. The current is curved, swifter than at Detroit, its velocity having been increased by the obstructions already placed in the river by the railway company, so that now it is five miles an hour at the railway company's pier on Stony Island, and about two and a half miles an hour in the main channel.

All objections arising from injury to navigation by a bridge at Detroit apply with still stronger force to a bridge at this place.

The general features of this section of the river may be gathered from the Table I and the accompanying remarks, and should any danger arise to the present ferriage system from the unfortunate location of their piers or the ponderous machinery of their ferry-boats, such difficulties could easily be obviated before the traffic of the road might require another mode of passage. The shallow water, while favoring the method of open coffer-dams in the construction of a tunnel at this place, would reduce its length much below that of the Detroit tunnel if it received the same gradients for its approaches.

The different railway crossings of the river have now been considered. Two bridges only are at present desired, namely, at Detroit and at Stony Island. As the road crossing at the latter point has but just been opened, we have no data for the amount of freight it will take over. From Messrs. Bissell and Hackett's statement, the amount of freight which would pass through a bridge at Detroit is about 9,000,000 of tons per annum, while from the Great Western Railway Company's statement the whole amount of freight crossed at Detroit in 1872 was less than one-tenth that amount. But what makes a bridge necessary to the railroads is the winter ice, as during the summer freight can be crossed about as cheaply by ferry as by a bridge, when interest on the cost of the latter and maintenance are considered.

Hence, supposing one-third of the railway freight to be crossed during the winter months, it will be seen, in case of a bridge, that 9,000,000 of tons of freight is asked to yield its interests for the benefit of one-thirtieth of that amount. This ratio will become larger when the Canada Southern Road is in full operation, but it must always be small.

But, aside from the relative amounts of freight whose interests are in opposition, there is a wide difference between the rates of transportation between points connected both by water and by rail.

From Chicago to Buffalo, during the season of navigation, there is the freest competition. The vessels engaged in freighting are of the most varied kind, their owners and managers are widely scattered, and almost as numerous as the vessels; and, when the rates of freight become high enough to make carrying a little more profitable, any man with a few thousand dollars can build a vessel and compete with the others.

A combination of any serious extent and long continuation becomes then impossible.

Among the railroad lines between Chicago and Buffalo, which are few in number, combinations to fix the rates of freight are easily formed. If the rates are too high, the fact that, to enter into competition with these, a capital of many millions of dollars is required, practically destroys such competition as would fix and keep the rates at the lowest practicable point.

The results of unlimited competition and water-transportation on one hand, and of no competition and rail-transportation on the other, are shown in the rates on grain from Chicago to Buffalo by water, in 1872, which varied, according to Messrs. Bissell and Hackett's statement, from 1.66 mills per ton per mile to 3.53 mills per ton per mile; averaging 2.74 mills, or about 12 cents per hundred pounds from Chicago to Buffalo, while the rail-rates by Blue Line were in October, 1872, 35 cents, and in May and September, 1873, 30 cents. In 1871 these rates varied from 22½ cents in summer to 35 cents in winter.

The earnings on through-freight of the Michigan Central Railroad are given in Table XVII, and in 1872 they average 12.80 mills per ton per mile.

The most pressing want of the whole Northwest is cheap transportation to the East, and no steps should be taken which can interfere with the main channel by which that transportation is secured. If we consider the magnitude of the freights which pass through the Detroit River as compared with those which in winter need a bridge to cross it, or if we compare the rates by which freight is carried between points like Chicago and Buffalo, common to the two routes, the immense importance of the preservation of the water-way unimpaired stands clearly forth. Bridges would be of an additional value to the railroads on account of the quicker time its passengers could make. This consideration is, however, of minor importance to the country at large, and especially to the Northwest, which demands, not the quickest passenger transit to New York across the Detroit River, but the cheapest freights on grain.

TABLE No. XVII.—*Showing the movement of freight, through and local, and earnings on same for the year ending May 3, 1873.—(Taken from report of Michigan Central Railroad Company for 1873, page 55.)*

Freight.	Tons carried.	Tons carried one mile.	Earnings.	Earnings per mile.	Earnings per ton per mile.
Total through.....	687, 673	189, 466, 925	\$2, 430, 695 16	\$8, 922 20	Cents. 1.23
Total local.....	729, 119	56, 611, 587	1, 422, 238 25	18, 318 37	2.51
Grand total.....	1, 416, 792	246, 078, 512	3, 852, 933 41	27, 199 81	1.57

For nature of this freight see page 52 of same report.

PLANS OF BRIDGES CONSIDERED.

The various forms of bridge that might be constructed across the channel will be considered and discussed under three separate heads:

1st. If the height to which the topmasts of all sailing-vessels might be reduced (without serious detriment to their sailing qualities) be taken to determine the headway of a high bridge, and the most economical length of truss as the measure of its spans, the former would be fixed at 150, the latter at 400, feet in the clear. The description and estimates for such a structure, adapted by Mr. W. S. Pope, president of the Detroit Bridge and Iron Works, to the circumstances of the Michigan Central Railroad, make the cost little less than \$9,000,000, which a further modification by the board reduces to \$8,000,000.

At no point do the river-banks rise to a height of more than 30 feet, and when we consider the additional motive-power required, the length and grades of the approaches, making the bridge equivalent to several miles of level road, and the great interest on cost and expense of maintenance, it becomes apparent that a high bridge, while still an obstruction to navigation, would be less desirable and more expensive to the railroad companies than the crossing by tunnels or by efficient ferry-boats, although, as a work of engineering, it would be practicable at any of the places above mentioned.

2d. Another form of bridge leaves a clear headway of only 12 feet, and is provided with two pivot-draws, each leaving two openings of 166

feet in the clear, and the remainder of the structure built on piers of masonry 200 feet apart.

At the first meeting of the board it was to a bridge of this form that the arguments of the railroad companies were directed, however their opinions or policy may have been altered by subsequent investigation. The cost of such a structure they fix at \$2,451,000 for Detroit, and it would be about the same for the other crossings.

The nature and magnitude of the commerce which would thus be forced through these narrow passages has already been described and compared with that of the largest sea-ports of the lakes and oceans. If the right of way were given to vessels passing through a draw, it would subject the railroad-trains to as severe a blockade as they have ever suffered heretofore from insufficient ferriage; thus, in the single month of June, 1873, as appears from the records kept by the board, there were three hundred and sixty-one times when the draw would have had to be kept open for 20 minutes or more; ninety-three times, for 30 minutes or more; twenty times, for 45 minutes or more, and once, for an hour and a quarter, to make way for vessels passing in one direction only. This is based on the belief that 12 minutes must be allowed for closing the draw, passing a train, and opening again. If it took 14 minutes to do this, there was one instance where the draw would have been kept open for two hours and a half; but the vessels passing in the opposite direction might keep open the other draw after the one just considered was closed, and thus still longer delay the passing of trains. Details may be seen in the graphic representation of passing vessels, accompanying this report.

The president of the Michigan Central Railroad proposed that the draw should be closed thirty times a day for a space of 10 minutes each, thus giving time for the transfer of all their trains, and throwing all the delay upon the vessels; but the wind and current will not permit the latter to remain long in a position to pass; and, for safety, at least 6 minutes must, on this account, be added to the time when the draw is actually closed or in motion, making 16 minutes in 48, or one-third of the day; thus stopping in their course, during the season of navigation, about 9,000 vessels, an obstruction altogether inadmissible.

But even if there were no stoppage, there would yet be great difficulty to tows, rafts, and sailing-vessels in passing draws.

The 8,500 steamers must slacken their speed, and the 3,500 sailing-vessels, which annually pass, must often come to anchor to wait for a tug to tow them through, or be drifted by the wind and current against the bridge. Of the 4,500 tows many must break up, especially under cross-winds, and be taken through in parts. Rafts might, perhaps, usually pass in safety with the aid of additional tugs, but would sometimes be wrecked by the operation, and the damage that would inevitably result from this and other apparent causes would soon reach a large amount.

* Some of the statistics of a draw-bridge at Chicago have been furnished to the board by the railroad companies, as evidence that a draw could readily pass the shipping of the Detroit River. They show that 43,735 vessels passed during the season of navigation of 1868. The detailed records for some months in 1873 show that more than half the entire number were tugs, and about half the remainder scows and canal-boats. A tug rarely takes through more than one vessel at a time. Two tugs are often required for one vessel. The current is almost imperceptible, the banks are only about 120 feet apart, are built up with docks on both sides, which serve as fenders and guides, the draw is not

more than about one-third the length of that proposed for the Detroit River and can be swung round very readily. For these reasons, no adequate comparison can be made between the Chicago draw-bridge and a draw-bridge over the Detroit River.

During the past season of navigation about 250 vessels ran aground in the old channel at St. Clair Flats. If a small fraction of this number were to strike the piers of the bridge proposed across the water-way, as the vessels would in some cases sink, the loss would be serious.

When it is considered that all these difficulties are largely multiplied by the increase of traffic on the river, and again by the increase of traffic over the bridge, the board is of the opinion that no bridge with draws alone for the passage of vessels should be tolerated across this water-way at any point.

3d. The board having suggested a bridge which should be continuous during the winter, when the railroads need the bridge, and during the season of navigation have a portion removed so as to give a clear way for navigation, a plan and estimate was made by Mr. Pope for such a structure.

The plan gives two movable portions, each 400 feet long. Each portion is made of two spans, the abutting ends being supported by a ponton, and the extreme ends resting on permanent piers of the bridge; during the season of navigation the pontoons and spans resting on them to be removed from the channel. The estimated cost was \$1,966,500.

In discussing this plan the board changed it by substituting for the pontoons movable caisson-piers, resting on permanent foundations at least 18 feet below the lowest known stage of water, the caissons being floated to their foundations, loaded and sunk at the close of navigation, and the trusses placed upon them. Two such piers to be used with three spans resting on them; the removal of the caisson part of the two piers and the three supported spans, at the opening of navigation, to give a clear water-way of 700 feet, measured at right angles to the current. Bridge to have 30 feet clear headway, the rest of it to have 300-foot spans, and with a pivot-draw with two openings of 100 feet each in the clear, near the American shore; this draw being kept constantly open during the season of navigation. The 700-foot opening to be, if practicable, in American waters. Such a bridge gives to navigation during the season a clear water-way 700 feet wide, while at Sarnia the river is only 800 feet wide, and at the Lime Kilns practically much less, for heavy vessels. To the railroads it gives a bridge during the winter months, when alone the need of a bridge is imperative.

The board deem a water-way 700 feet wide during the season of navigation sufficient to accommodate the commerce in question without serious inconvenience, and they therefore think the bridge just described admissible, so far as the interests of navigation are concerned, without being so costly as practically to prohibit its construction to a railroad company. But while it suffices for the needs of the railroad, it requires the ferry system to be kept up, and is a bridge useless to it for eight months in the year; while it is not a grave obstacle to navigation, it yet cramps a noble navigable river, which if it had been formed by art would have been held as of priceless value; it diminishes its width by two-thirds and places in it permanent obstacles to navigation.

CONCLUSIONS.

The conclusions to which the board has arrived are, then—

1st. That a bridge giving a clear headway of 150 feet, and clear spans

of 400 feet, would not seriously injure navigation, but would be very expensive, involving long and in some places inconvenient approaches.

2d. That no bridge giving passage to vessels by draws alone, with draw-spans at present practicable, can be permitted without serious injury to navigation.

3d. That a bridge giving a clear opening of 700 feet from April 1 to December 1, with two draw-openings 100 feet in the clear, and with the permanent foundations of its movable piers 18 feet below lowest stage of water, will not be a serious obstacle to navigation.

4th. For the reasons heretofore given, although the question has not been directly referred to it, the board deem the crossing of the river by tunnels the only unobjectionable method; and from all the information they have obtained, think a tunnel at Detroit or Stony Island is by no means impracticable, at a cost not so great as to debar its construction.

Finally, the board would remark that at no place between Lakes Huron and Erie should a bridge be permitted which would give less facilities to navigation than the one already discussed, having 700 feet clear opening; that no construction should be commenced without prior approval of the plan and location by the Secretary of War; that, under his direction, the construction should be so carried on as during its progress to give least obstacle to navigation; that the opening of 700 feet should be kept clear to navigation from April 1 to December 1 of each year under severe penalties; that as a portion of the opening might be in Canadian waters, to control this portion so far as the interests of American commerce are concerned the United States should reserve the right at any time to stop the running of trains across the American portion of the bridge.

All of which is respectfully submitted.

G. K. WARREN,

Major of Engineers and Bvt. Major-Gen.

C. B. COMSTOCK,

Major of Engineers and Bvt. Brig.-Gen.

G. WEITZEL,

Major of Engineers and Bvt. Major-Gen., U. S. A.

W. E. MERRILL,

Major of Engineers and Bvt. Colonel.

W. R. LIVERMORE,

Captain of Engineers, Recorder.

Brig.-Gen. A. A. HUMPHREYS,

Chief of Engineers, U. S. A.

The following papers are herewith transmitted to accompany the report:

I. Report of James F. Joy, president Michigan Central Railroad Company, to the Board of Engineers, concerning the interests of the railroad companies in bridging Detroit River.

II. Statement of G. W. Bissell and Robert J. Hackett.

III. Opinion of Franklin Moore, lumber-dealer, on the proposed scheme for bridging Detroit River.

IV. Opinion of R. A. Alger on the same.

V. Opinion of R. W. Gillett on same, and statements of facts concerning the commerce of the lakes.

VI. Opinion of Mitchell B. Kean, tug-owner, of effect on vessels of a bridge over Detroit River.

VII. Opinion of Allen Sheldon, wholesale dry-goods merchant; W. B. Dickerson,

produce merchant; and Duncan Stewart, (J. S. Hurd & Co.), grain merchant, concerning bridging Detroit River.

VIII. Statement of Willard S. Pope, civil engineer, concerning bridging Detroit River.

IX. Statement of same concerning relative merits of high and low bridges over Detroit River.

X. Proposal by A. B. Maynard and E. W. Meddaugh on behalf of Michigan Central Railroad and Canadian Southern Railroad to accept a grant from the Government allowing said roads to build winter bridges across Detroit River, with two openings of 400 feet each, and a draw of 166 feet to each bridge.

XI. Report of paper read by E. S. Chesebrough on Detroit River tunnel, before Civil Engineers' Society of Louisville.

XII. Answers by F. N. Finney, Chief Engineer Canada Southern Railway, to questions proposed by Board of Engineers to railroad and bridge companies.

XIII. Statement of W. R. Clinton, master ferry-boat Victoria, in favor of ferrying cars across Detroit River.

XIV. Statement of Joseph Nicholson, vessel-captain, against bridging Detroit River.

The following drawings are herewith transmitted, to accompany the report:

I. Vessels passing Detroit, Mich., (No. 37.)

II. Diagram showing traffic on Detroit River, from record kept at Grosse Isle by Canada Southern Railroad.

III. Diagram showing number of cars ferried weekly at Windsor by steamers Great Western, Transit, and Saginaw, from 1869 to 1873.

IV. Map of crossing of Canada Southern Railroad, &c., furnished by Canada Southern Railroad Company.

V. Plan showing Canada Southern Railway crossing St. Clair River.

VI. Plan showing Canada Southern Railway crossing Detroit River.

VII. Chart of Detroit River, showing railway connections, currents, &c.

VIII. Profile of Detroit tunnel.

IX. Profile of Detroit River, lines A, H, P, R.

X. Plan showing draw and fixed spans across main channel, Detroit River, furnished by Canada Southern Railroad.

XI. Detroit bridge, Plans Nos. 1, 2, 3, furnished by Willard S. Pope, for Michigan Central Railroad.

I.—REPORT OF MR. JAMES F. JOY, PRESIDENT MICHIGAN CENTRAL RAILROAD COMPANY.

To the Board of Engineers appointed to investigate and report as to bridging the Detroit River:

There are invested in the railroads whose outletting point is Detroit, and whose business crosses the river at that point from the west, including the Michigan Central and roads tributary to it, (the Detroit and Milwaukee, Detroit and Bay City Road).....

In the Great Western, now in and to go in this year.....

\$65,000,000

35,000,000

100,000,000

The main portion of this capital is invested in roads whose chief business is the transportation of the productions of the country, and merchandise and passengers, between the East and the West. This investment has been made as the necessities of the country have required, and must continue to increase as the country becomes populous and expands, and none can estimate the limit to which it will reach, provided a passage of the river by means of a bridge can be effected.

The expense of transportation has been so much diminished of late years that the grains of the West, as well as other productions, are rapidly changing from water to transportation by rail; and especially during the five months during which navigation is closed, the trains of all the roads are overburdened by the immense volume of this kind of business. The extent of it may, to some extent, be estimated from a statement made by the Chicago Board of Trade, in a petition to Congress for a new road especially for freight, a copy of which is appended hereto.

Many millions of bushels of grain are annually locked up each winter at Chicago and other lake-ports for want of transportation, and the distress is so great that efforts are actually being made to induce Congress to grant the money necessary to build a new double or fourfold track all the way from Chicago to the seaboard for the relief of the country from this annual stoppage of this immense business. Consider for a moment the necessities of the millions of people whose productions are thus stopped on their way to market some months in every year, and the expense also to which they are subject for storage, loss of interest, and other charges to which they are compelled to submit. Though it is not easy to state the amount of loss, or damage, or expense caused to the agricultural community by reason of this cause, yet it is not difficult to see that really it will take the damage and loss of not many winters to amount to all the value of all the shipping afloat upon the lakes.

In the latter part of January, 1865, after the winter's blockade, and the rivers were opened, and before the ice passed from the lakes and the Straits of Mackinac, the business of the West was moving eastward upon the railways in a large volume. The price of all kinds of produce was ruling very high, as well as of beef and pork. Just at that time a flood in the Genesee River swept away the New York Central bridge at Rochester, and all the business finding its way out by that avenue, by the roads both north and south of Lake Erie, was brought to a stand. All depots, and trains upon side-tracks, on both lines, as far back as Chicago, were filled with valuable property which could not move, as were all the store-houses in the lake cities. It was nearly four weeks before the bridge was restored and the trains could freely move, and about as much longer before the cars going East could return and be employed in the regular business. In the mean time prices fell off, perishable property was much injured, and the losses were very large. Indeed, it was estimated that the losses to the shippers of western productions to the seaboard and to the agricultural portion of the West in that year, from this cause alone—the stoppage of the movement of produce East for only four to six weeks—was enough in amount to have built another road such as the New York Central Road was at that time.

It is safe to say that with uninterrupted trains, and with a bridge across the Detroit River, three or four or five, and perhaps ten times as much property would pass the river every winter in the same period of time as was then stopped by that calamity. For the business which will pass by rail through Detroit is not to be measured at all by the past, when it could not move sometimes at all, and never with facility during the winter months, but by the ability of a double-track road between Chicago and New England and New York, moving across the river by a bridge, and therefore not subject to interruption, upon which road full trains may be as they are now moving on the New York Central Road, both ways at the same time, and not more than twenty minutes apart from each other. Estimating the capacity of the roads by that standard, and with such frequent trains and constantly moving, and it will be difficult to even value the amount of business to be done or the immense relief it will be to the whole West during the four or five months when the navigation is usually closed, and with four or five such roads north and south of the lake constantly at work, night and day, for that time, the relief given by property reaching market and sales, by saving interest, cost of storage, and other charges occasioned by delay, will be of the most incalculable value to all the West. It will be felt upon every farm, and by every business man, in fact by every inhabitant of the great Northwest, and through all the arteries and channels through which business of any kind moves and money circulates through the whole western country.

It would not only be a relief of such incalculable importance, but it would affect the price of transportation by water all the rest of the year. The store-houses of the West would be continually drained during the winter. There could be no such accumulation as now takes place of many millions of bushels of grain at a single point in a single winter. The flow of produce East would be constant, and spring would open with little or no surplus at the shipping-points, and when at last navigation should open, there being no large accumulation, the price of freights would not be from 15 to 20 cents between Chicago and Buffalo, as they were nearly all last year, and at the opening of this season, but from 2 to 5, and the effect would be felt all the summer through. In this way the saving to the West would each year be simply enormous. There might not be, it is true, so many vessels upon the lakes, and the width of the draws of bridges possibly might not be considered so important as vessel-owners seem now to consider them. There might not be a vessel of some sort every five or ten minutes passing up and down the river, but the gain to the people of the West in every aspect of the case would be almost incalculable.

Now the time during which the Straits of Mackinac are closed and navigation is obstructed was last winter five months, and is rarely less than four, and will probably average from four to five, more than a third of the whole year by considerable. Shall trade and transportation stop during that time to suit the vessel-owners and enable them to reap a richer harvest from the millions who earn their bread by the sweat of their brows during the rest of the year—and they do not hesitate always to take all they can

get—and if it must stop why shall it stop? Can there exist any necessity so great as to justify such a stoppage and subject so many millions of people to such inconveniences, and such damage and loss, amounting, to say the least of it, in money, to a great many millions every year? It does not seem possible.

Let us examine the reason. It is not certainly in the amount of money invested in shipping upon the lakes. The highest estimate of all the shipping afloat is \$50,000,000.

There are at least \$100,000,000 of railway property interested in the crossing of the Detroit River at Detroit, and there are probably \$50,000,000 which will be interested in the passage at Trenton, including the western and southwestern connections, which will outlet there. If, therefore, the value of the property interested in this question alone is considered, there are at least three times as much in the railways as in the shipping.

Shall the interest of the \$50,000,000 weigh down and obstruct the business and the revenues of the \$150,000,000, and thereby depreciate and affect its value, or should the larger interest outweigh the lesser one, if either is to be affected by the proposed bridge? This does not seem to be right or fair.

If the interests of the public alone are to be the criterion, and if those who have money invested in vessels and railroads are to be laid aside in the consideration of public policy, how will the case then stand?

Let us take the passage of the river at Detroit, by means of a bridge, to test the question. Let us suppose such a bridge as we think necessary at the foot of Second street, built across the river with one or even two draws, by means of bridges resting on a pivot-pier, and having openings of 166 feet in the clear on each side of the pivot, and there being four such openings for the passage of vessels, and the bridge, consisting of spans of, say, 300 feet long, otherwise than at the draws, and the bridge being a low bridge, say from 10 to 20 feet above the water. Let us compare the evils which the millions of producers in the West will suffer by reason of such a bridge, and those which they now suffer and must continue to suffer by the want of it.

First. There will be no perceptible inconvenience to any and all vessels going up stream, and no increase of expense of navigation in that direction. The almost universal mode of passing the Straits of Detroit, and so elsewhere, also, is by tugs taking a line of four or five, or less number, of vessels in a line, and drawing them up or down the river. They go always up in a straight line, and could easily go through a passage 66 feet wide, instead of 166 feet wide. The only contingency in which there could possibly be any inconvenience would be when up and down tugs might meet, and desire to pass the same opening at the same time with their vessels in tow. In stormy weather there might possibly be some difficulty in both passing the same opening. There would be none in any other weather. But there will be an opening on each side the pivot-pier of 116 feet, and they need never meet in the same opening.

Tugs, both ways, should pass through the right opening, and they could never meet. And the two openings of a single-draw bridge upon a pivot-span would be ample for the passage of all the boats and vessels engaged in the navigation of the lakes in the usual course of business. Going up, therefore, there can be no difficulty, or trouble, or inconvenience.

It is contended that there would be some going down with a line of tugs. Let us examine this question and see how much difficulty there would be:

First. There would be none when the draw was open. We assume that whatever the weather when a tug is manageable, and navigation can go on, a tug (and they are always strong and powerful, passing through the water by the power of steam) will pass enough faster than the current to keep the vessels in line. This is always the case, and with a man at the helm of each vessel and a powerful tug pulling, it would be totally impossible to get out of line, except purposely, even going down. With the draws open, therefore, perpetually there could be no difficulty. In pleasant and ordinary weather, and with the open draw, there would be no possibility of difficulty, of course. In going up, the tug can always go fast or slow on approaching the draw, as it pleases, and should a train be passing it would only have to slacken speed for a moment or two till the train had passed and the draw again opened. In going down, if a tug approached when a train was passing, it could not stop, of course; and if so near that it could not continue its course, it might be compelled to round to and start downward again. This is the whole extent of the inconvenience there could be, and it remains to consider how important it will be. It is the most common thing for tugs with their tows to round to, and tie up to the shore or wharf. They do it for wood. They do it to go and help other vessels. They do it to obtain supplies. It is the work of only a few minutes at most. It is not expensive, but might involve a loss of time, say from fifteen to twenty minutes at the outside.

How often would this occur with a bridge, and how much would navigation suffer by it? And in discussing this question we will adopt the extreme statements of the vessel-owners, that the passage of vessels averages one every six minutes during navigation. This includes tugs and craft, big and little, of all kinds.

In the first place, we will state a fact which bears upon the case somewhat. All the trains of the Chicago and Saint Louis Railroad and of the Pittsburgh and Fort Wayne

Railroad run over a single-track bridge over the Chicago River, where there are an immense number of vessels passing up and down with tugs. Those roads both do an immense business, and a very great number of trains pass across the bridge. In 1868, when there was not probably half the business there now is upon those roads, between March and December the draw was opened for the passage of vessels 16,984 times, and 43,735 vessels of all craft passed through. This was done without serious inconvenience to either the roads or vessels. The time was eight months, and calling each month thirty days, there were 345,600 minutes in the time, and there was a vessel passed through during that whole period in every seven to eight minutes. With the increase of navigation this number is doubtless largely increased, and it is possible that there is one every five minutes, and yet there is no trouble for the railway or navigation which materially affects either. Now, as has been stated, a tug generally takes in tow five vessels, and averaging from three to five, say on an average four, and including the tug, there are five vessels generally. This reduces the number of passages at once to one in a half an hour, and we venture to state they will not average that during the year. Now, during the season when the navigation is fully open the draw would be kept open for the passage of vessels, and there could be no delay except during the actual passage of trains, and we estimate that for the present the draw would be closed thirty times a day, and for a period each time of about ten minutes, in all the twenty-four hours, say five hours out of the twenty-four. This will be at regular stated periods of the day, and will come to be understood, and the result will be really no inconvenience, because tugs will know all the time when to approach the bridge, and they will have nineteen hours out of the twenty-four to pass and repass, and they will pass, on an average, only once in half an hour in any event. It is not at all probable that there would be any difficulty or real substantial inconvenience to any interest more than there is at Chicago, where there is quite as much passing and repassing of vessels through many draw-bridges as there can be here. Indeed the passages will be, and are, more frequent there, because tugs rarely take more than one or two vessels there at a time. Here they will take from three to five, as above stated. There will not be, it is safe to say, one out of fifty tows which will be required to round to at all, or slack up in a direct course. If there be so many as that, that one in fifty might possibly be delayed a half an hour at the outside, and then would pass along. This is really the extent of the injury to navigation, and the whole extent; and it is safe to say that if there were twenty such bridges across the river between Lakes Huron and Erie, the injury to the agricultural community of the great West, whose interests are principally invoked, would not be half or a quarter as great as the interruption of railway passage by ice for a single month in any one winter would occasion. The injury caused by the bridges would be imperceptible upon the business and upon the value of the productions of the country. The stoppage of the trains for a single winter, and sometimes even for two or three weeks, is, as has been shown, immense. And when we consider the immensity of the benefit to all the West of uninterrupted and constant trains running upon double-track roads all the year round, and especially in winter, when all other means of transit are closed, and that the productions of the West can only move by rail, and the effect upon business and trade, and upon the comfort of every industrious farmer of the West, and every merchant and mechanic, resulting from uninterrupted and constant movement of traffic, and consequent circulation of money in the West, the argument is overwhelming, and cannot be resisted, in favor of a bridge or bridges wherever necessary.

Let it be borne in mind, also, that there is no change in the current of the Detroit River—there are no floods there. The flow of the current is gentle and uniform, and always alike. There is no river in the world where, from those causes, a bridge would be so little interruption to navigation. There are no eddies or side-currents to take a vessel out of its course and drive it against a pier. Everything favors the easy and perfectly-safe passage of vessels of all kinds through a draw.

This argument has all been based upon a single draw with two spans, which are amply sufficient for navigation. But at Detroit we propose two, both equally convenient for navigation, and one near the Detroit side, while the other should be in the thread of the stream, or mid-channel. The one near the Detroit side would, besides admitting the free passage of vessels engaged in the long navigation of the lakes, admit the free passage up and down of vessels moving locally in the port of Detroit.

Now, for a moment, set the disadvantages to navigation by a bridge against the disadvantage to the railway by being without one. The whole sum of disadvantage to navigation is, that possibly, in the course of the year, some tows going down may be compelled to round to and be delayed in their passage by that cause possibly half an hour each. This might or might not occur, and would certainly occur rarely, and the effect on the general business of the country would be inconceivably small, and not in the slightest degree perceptible. Last winter the trains were obstructed by ice in the Detroit River about two months, and the business from the West was totally stopped in consequence about three months. The cars of the railroad companies to the number of 3,000 were accumulated on the borders of the river and on the side-tracks of the railroad waiting passage. We estimate that this obstruction cost the Michigan Central

and Great Western Roads, in business, about a million dollars. The obstruction probably obstructed the passage of property to the amount of from twenty to fifty times that for the period of three months which it took to clear roads, get cars back, and get business moving again freely. The loss in damages, delays, costs, and loss of interest was immense, and the large amount of money represented by that amount of property was kept out of circulation in the West during that time; and it is safe to say that the price of every bushel of grain in the whole West, and the amount of every man's business, and the comfort of every household there was affected by it, while the railroads, whose losses were minute when compared with the effect upon the country in general, were many hundred times greater than would be all the damage to navigation in twenty years occasioned by any number of bridges ever likely to be built between Lakes Erie and Huron. These results, so far as the railroads and community are concerned, are from actual experience. All the possible inconvenience to navigation which can result is perfectly apparent. Yet, in these circumstances, the vessel-owner will, if he can, continue to subject the railroad companies and the ten millions of people in the North west to these great losses, to avoid the almost infinitesimal inconvenience to which they may possibly become subject if a bridge is built. It cannot be necessary to argue this question further. Nothing which can be said will add to the strength of the case beyond that given it by a simple statement of facts and resulting consequences.

As to the place where the bridge should be built, we have to say that at Detroit it should be at the foot of Second street, and directly across the river, at right angles with the current. If not there, it must be two or three miles above or below the city. Either would occasion great inconvenience. Trains from Detroit east would be compelled to run back into the country some miles to start, and trains to and from the West and East would have to break up outside the city, and only the part destined for Detroit would come into it. In both passenger and freight business the inconvenience and additional expense would be very great. If the bridge were at the foot of Second street the trains would only stop at Detroit, between New York and the West, to take on and let off passengers, and their passage would be continuous along the same track, which would be an immense advantage both in passenger and freight business. The plan hereto appended will show what we desire for the Central and other roads centering at Detroit. The grade should rise gently to the border of the river, so as to place the bridge, if possible, say twenty feet above the river.

With regard to the tunnel, we have to say that it was given up, because there was no reasonable hope that it could be built in any tolerably short period of time, if by possibility it could be at all. The chief engineer, Mr. Chesborough, determined not to commence the main tunnel till the small tunnel built for drainage and exploration was through. That was estimated to cost \$70,000, and the time to complete it six months. The time which had been spent upon it was near two years, and the money expended, \$135,000. There remained about 1,700 feet to go with the work, and the utmost per day which had been accomplished for some weeks was one foot, and the work was becoming more and more difficult. There was no way by which it could be hastened. Mr. Chesborough stated that it might take six years to accomplish it. If the work could be carried through at all, probably the main tunnel could not have been completed short of ten years. Mr. Chesborough's estimate, last made, for the cost of the small tunnel was \$200,000, instead of \$70,000, the original estimate. The original estimate for the main tunnel was \$2,600,000, but, judging from the past, it would probably cost three or more times that. No well-based estimate can be made of the cost of the work about which there are so many contingencies a hundred feet below the surface, and under such a river as the Detroit.

The data relative to transportation of freight by ferry-boats, and costs, &c., and amount of freight, will be furnished by the Great Western Company. The amount of freight carried under present disadvantages is no criterion of the amount which will be carried with a double-track bridge, over which trains can pass freely at all times during the winter. Then it will be immense, and it will be safe to say that with the means of doing the business now being prepared by means of four great roads, of which three are being double-tracked and two of which are north and two south of Lake Erie, there can be and will be no accumulation of grain in the lake cities. It will move all winter. There will be no stagnation of business during the winter months. The great roads will be always open. Freights will move all the time. The business of the country will continue through the year round. There will be little cost of storage, little delay or loss of interest. Money will continue to circulate in the agricultural country during all the year. The market for the farmer will be always open, and he will be able to command money for his productions in winter as well as summer. Life, business, and energy will be as apparent, and the internal commerce of the country will move as rapidly in midwinter as at any other season of the year.

In closing we will remark that, by reason of the policy of Government, the agricultural community are taxed to support almost every other industry. There is a protective tariff, which fosters almost every species of industry except the cultivation of the soil, and at the expense of him who cultivates it, and, while that is done, every inducement is held out to the emigration of the world to come to this country and help swell

the enormous volume of the productions of the soil, until the overproduction is such that they will hardly bear transportation to market. Homestead laws are passed, free lands are given, to induce emigration and competition in the business of farming. While all other industries are protected at the expense of the large farming population of the country, the value of their productions is depressed by an equal, and perhaps even stronger, stimulus in the shape of homesteads, to tempt him to come here and multiply the productions of the soil. In a double manner is the production of his industry affected. The only possible protection or favor he can receive at the hands of Government is to remove the obstacles in the way to market, and, if possible, procure for him cheap, and, what is of equal and perhaps more importance, by ever-open and adequate roads, to the great markets of the world. That the roads that we represent may be made such, and put in the best position to accomplish these ends, it is that we ask to be permitted to bridge the Detroit River, and keep forever, and at all seasons of the year, one of the old and great avenues over and through which can best pass as large a share of the immense volume of western productions as can be transported by any one line of railroad.

As to the site of the bridge, we have to say that, in the judgment of the railroad companies, it should cross the river at the foot of Second street and run across at right angles with the current. The river is so wide and so spacious, and so uniformly deep, that in either portion of the river in front of the city, above or below a bridge so located, there is ample room, probably, for all the vessels upon all the lakes at any one time. All boats can round to above or below. All vessels will be able to approach any wharf above or below, and with no material inconvenience. So far as any interest connected with navigation is concerned, the precise location is not important. So far as the railroads are interested, and the city of Detroit, the location on this site is of very great moment.

First. With regard to the railroads, I have to say that that is the only site within the city where the passage can be made, and if it be not made there, it must be far above, at Belle Isle, or below, near the fort. Either of these would involve large additional cost and subject the railroads to very great inconvenience. All the roads terminating at Detroit must run their business some miles out of the way to reach the bridge, except the Michigan Central, with its through business. The business of the city of Detroit to and from the east, both travel and passengers, would be compelled to run back on one or the other roads three miles or more to reach the track leading to the bridge, whether it should be above or below the city. This would place the roads east from Detroit and the business of that city to such a disadvantage as to compel the maintenance of ferries in the summer to obviate it, and there would be involved the double expense of both ferry and bridge. This would be inevitable, and the bridge would be reduced mainly to a winter passage-way.

The effect upon Detroit itself would be disastrous. If the bridge were used for the through business, the trains for that business would never pass through the city, but some miles away from it, and the roads to the city would become switches or side-tracks from the great through route, extending into the city for such business as was purely local. All the business to and from the city east, in the winter, as has been said, would be compelled to reach these side-tracks from three to five miles out, increasing the distance between it and the seaboard from six to ten miles, and to avoid which in the summer ferries would be kept up. Detroit would cease to be upon one of the great thoroughfares of the country, and would be placed, aside from that, at a very great disadvantage. That this would be the case we need not argue at any length. Every man and every citizen will realize it at once from the simple statement of the case.

All advantages are in favor of the location at the foot of Second street. That location will disturb no existing values in property. The business of the country will continue to approach the city in the same manner and at the same places as heretofore. The trains, both through and local, will not be disturbed or broken up outside, a part to run to the bridge, and a part to run into the city. The track of the great railroad route through the city from Chicago to New York, and *vice versa*, would be continuous. Freight and passenger trains either way, for through business, would continue through, without being compelled to back or run back to get upon another track. The travel and business to and from Detroit would take the through train as it passed along. It might also, in the winter, when the interest of navigation did not require its draws to be kept open, and when the passage of the river at all times is difficult and unpleasant, and much of the time impossible, be used as a highway for travel and business of all kinds, and would in that aspect be valuable to the public. Every argument from convenience, necessity, and the public interest, in every form, points to that locality as the site of the bridge, and fixes it there so firmly that any other seems impossible.

Such are the reasons respectfully submitted to show why there should be built a railroad-bridge across the river to Detroit, and also why it should be located at the foot of Second street, and for which we request respectful consideration.

With the utmost respect,

JAMES F. JOY,
President of the Michigan Central Railroad Company.

MEMORIAL TO CONGRESS.

To the Senate and House of Representatives of the United States:

We, the undersigned, citizens of the several States named below, would most respectfully present this memorial:

During the winter months, for years past, there has been a pressing want of increased transportation facilities from the West to the seaboard. The railroad companies have been unable to receive and transport all the property offered them, and their inability to meet the demands upon them for transportation has induced them to exact largely increased rates of freight, with results alike damaging and disastrous to the agricultural, manufacturing, and business interests of the entire country. The immense elevators and grain warehouses of Chicago have been (in midwinter) filled to overflowing, compelling them partially to suspend business, so that the railroads bringing grain from the West to Chicago have been unable to unload their cars, and consequently they have been obliged to refuse transportation to their patrons.

The warehouses in the country becoming full, farmers have, in many instances, been unable to find a market for their grain. This winter-freight embargo has also prevented the western pork-packers and provision-dealers from realizing on millions of dollars' worth of property wanted in European markets. The impossibility of shipping said property when ready for market has resulted in severe stringency in money matters, deranging and damaging business and causing financial embarrassment. We would, also, respectfully remind your honorable bodies of the rapid increase of population, and of the agricultural growth and industrial pursuits of the vast territory (more than 600,000 square miles) between Lakes Michigan and Superior and the western boundary-line of Nebraska, which, to a very great extent, is tributary to Chicago in all business matters, and through which city the major portion of the surplus products of that section of the country must pass during the season of suspended navigation of the lakes and rivers to reach the great markets of the Atlantic States and Europe. We have observed with pleasure the several propositions for enlarged and additional water facilities between the East and West to mutually benefit the producers and the consumers of our produce. But we are convinced that water-routes alone, however improved and enlarged, will not fully answer the purpose desired, especially in this northern latitude, where lake, river, and canal navigation is suspended for more than one-third of the year, which turns the entire transit business on to the present railroad-lines, greatly overtaxing their rolling-stock, at winter rates of freight, the effect of which, as has been shown, is to check grain-shippments to the East, thereby filling the large warehouses in Lake Michigan ports at long-storage rates, with grain at low prices. The farmers who can hold their corn-crop until the next spring can store it at home for better rates at the opening of navigation; but those who cannot do so must often sacrifice their best interest to meet current expenses and payments, while, at the same time, the consumer at the East is obliged to pay prices out of proportion with those received by the producer, because the present facilities for transporting property are inadequate to move all that is pressing forward, and likewise insufficient to move the quantity demanded by the wants of the East.

What we need, and must have, as it appears to us, to afford proper relief to all interests, is a double-track railroad between Chicago and New York, to be worked exclusively in the tonnage business, at slow speed and at cheap rates. This road, worked at about seven miles to the hour, would carry from Chicago to New York, every year, a tonnage equal to *four hundred and fifty million bushels of wheat*, and return as many tons to Chicago. In case Congress is not prepared to order the construction of such a highway as a national public work, we humbly pray your honorable bodies to grant a charter for the construction of such road, with judicious and proper restrictions as to capital stock, toll-rates, speed of trains, and impartiality in the reception and transportation of freight.

In the judgment of your petitioners, said charter should require the company (to whom it may be granted) to receive and transport over its line, with reasonable dispatch and at prescribed maximum and uniform rates of toll, all cars (whether loaded or empty) corresponding in gauge and construction with its own, or of a certain specified standard of construction. The charter, also, to require of the company complete and full responsibility in the care and delivery of all property which it receives. The charter, also, to require the company to make annual reports to the Secretary of the Interior of all its operations, including detailed statements of its capital stock paid in, its receipts and expenditures, and such other information as may be required by the said Secretary of the Interior; and that the Government, by order of the said Secretary, or by vote of Congress, to have at any time the right to investigate all the affairs of said company, for the purpose of verifying said reports, or for other purposes.

In the establishment of rates of toll for transportation, the company should be allowed to exact only so much as will, in the judgment of its managers, approved by the Secretary of the Interior, produce a net revenue of not exceeding 12 per cent. per

annum on the actual cost of the road and equipment; and no dividends to be made exceeding 12 per cent. per annum, any surplus earnings over the amount so divided being carried to a surplus account, to be applied to future dividends, producing corresponding abatements in the traffic-rates.

And your petitioners will ever pray, &c.

II.—STATEMENT OF MESSRS. G. W. BISSELL AND ROBERT J. HACKETT.

To the Board of Engineers :

GENTLEMEN: We herewith submit our report of the commerce passing through the Detroit River in 1872. This report is made from information derived from the custom-houses, and boards of trade, at Chicago, Milwaukee, Detroit, Toledo, Sandusky, Cleveland, Erie, Buffalo, Tonawanda, and Welland Canal.

Our statements are from absolute data, except as to "general merchandise." This item we believe to be much larger than we have estimated it. Our information as to the number, tonnage, and value of the different classes of vessels is from the underwriters' books; but there are some 100 scows not on their books, and consequently not here reported. There were 52 foreign vessels that entered the port of Chicago during the season of 1872, not included in this report.

We beg leave to call your attention to the statements of Captain Mott, (hereto appended,) who has charge of the St. Clair Flats Canal. We think the facts given by him, as to the delays and difficulties at that place, conclusive as to the damage to navigation that would result from four or five bridges across Detroit River.

Detailed report of the commerce passing through Detroit in 1872.

LUMBER.

For Detroit	42,667,000 feet.		
In rafts	100,000,000		
For Toledo	89,781,349		
For Sandusky	65,389,000		
For Cleveland	200,000,000		
For Erie	20,140,000		
For Buffalo	200,000,000		
For Tonawanda	175,000,000		
For Welland Canal	79,000,000		
		971,977,349	1,943,954 tons.

COAL.

From Sandusky	13,336 tons.		
From Cleveland	314,540		
From Erie	349,933		
From Buffalo	385,387		
From Welland Canal	46,000		
			1,109,196

GRAIN.

From Chicago	59,354,268 bush.		
From Milwaukee	13,579,101		
From Detroit	1,692,198		
From Du Luth	412,000		
From Racine	56,000		
From Sheboygan	53,000		
		75,146,567	2,028,857
			5,082,007

FLOUR.

From Detroit	75,000 bbls.		
From Chicago	223,467		
From Milwaukee	501,567		
		800,034	86,403

IRON-ORE, SCRAP, PIG, AND RAILROAD IRON.

Gross tons to Detroit	56,648
Gross tons to Toledo	5,789
Gross tons to Sandusky	8,720
Gross tons to Cleveland	458,771
Gross tons to Erie	267,044
Gross tons to Buffalo	31,722
Gross tons to Welland Canal	51,323

985,621

SALT.

Syracuse and Saginaw to Detroit....	65,000 bbls.		
Saginaw to Toledo	56,000		
Saginaw to Cleveland	45,000		
From Buffalo to Upper Lakes	250,000		
From Welland Canal to Upper Lakes.	200,000		
		616,000	92,400 tons.

STAVES.

Shipped to Erie	2,922 tons.		
Shipped to Buffalo.....	90,688		
Shipped to Welland.....	15,083		
			108,693

RECEIVED AT DETROIT FROM SMALL SAIL-VESSELS.

Wood, 3,235 entries	201,289 tons.		
Sand, 716 entries	39,431		
Stone, 371 entries	33,146		
Stone from Sandusky and Kelly Island.....	99,602		
			373,468

GENERAL MERCHANDISE.

To and from Toledo	15,789 tons.		
To and from Sandusky.....	6,000		
To and from Cleveland	150,000		
To and from Erie	125,000		
To and from Buffalo	330,000		
To and from Welland Canal.....	250,000		
			876,789

Entered at the port of Detroit full cargoes, part cargoes, and no cargoes not included heretofore:

4,897 entries of vessels of 150 tons and under.....	328,717	
2,271 entries of vessels over 150 tons.....	1,182,472	
		9,116,570 tons

There were 3,630,000 tons more freight carried down than were carried up.

Number of vessels and tonnage.

1,542 sail-vessels	338,924 tons		
529 steam-vessels.....	136,863 tons		
134 new vessels, steam and sail.....	134,000 tons		
			609,787 tons
2,205 whole valuation.....	\$36,765,000		

Freight on wheat per bushel from—

Chicago to Buffalo.	Freight per ton.	Freight per ton per mile.
April 1, 7 cents }		
April 15, 6 cents }	6½ cents, \$2 16.6.....	\$0.002 54 2 mills 54
May 6, 4 cents }		
May 20, 4½ cents }	4½ cents, \$1 41.6.....	\$0.001 66
June 3, 4½ cents }		
June 17, 6 cents }	5½ cents, \$1 79.1.....	\$0.002 10
July 1, 5½ cents }		
July 15, 7 cents }	6½ cents, \$2 08.3.....	\$0.002 45
Aug. 5, 7 cents }		
Aug. 19, 6 cents }	6½ cents, \$2 16.6.....	\$0.002 54
Sept. 2, 6 cents }		
Sept. 16, 9 cents }	7½ cents, \$2 50.....	\$0.002 94
Oct. 7, 12½ cents }		
Oct. 14, 13 cents }	12½ cents, \$4 25.....	\$0.005 00
Nov. 4, 9 cents }	9 cents, \$3 00.....	\$0.003 52
Average.....	\$2 33.....	\$0.002 74

Condensed report of the commerce passing through Detroit River in 1872.

Lumber, aggregate tons.....	1,943,954
Coal, aggregate tons.....	1,109,196
Grain, aggregate tons.....	2,028,857
Flour, aggregate tons.....	86,403
Iron-ore, scrap, pig, and railroad iron, aggregate tons.....	985,621
Salt, aggregate tons.....	92,400
Staves, aggregate tons.....	108,693
Received at Detroit in small vessels.....	373,468
General merchandise.....	876,789
Entered and cleared at Detroit in small vessels.....	328,717
Entered and cleared at Detroit in large vessels.....	1,182,472
	9,116,570
Whole number of vessels 2,205, tons.....	609,787
Whole valuation of steam and sail vessels.....	\$36,765,000
Average freight per ton on grain from Chicago to Buffalo.....	\$2 33 $\frac{1}{4}$
Average freight per ton per mile, 2 mills $\frac{7}{10}$.	

The vessel business both in numbers and capacity is increasing quite as rapidly as the railroad business.

ST. CLAIR FLATS CANAL, July 16, 1873.

DEAR SIR: I can safely say that thirty vessels per month get aground in the old channel over the St. Clair Flats during the entire season of navigation; this is on either bank, exclusive of what ground in the center of the channel.

W. H. MOTT,
Custodian St. Clair Flats Canal.

L. W. BISSELL.

ST. CLAIR FLATS CANAL, July 11, 1873.

At the request of Mr. J. B. Bloss, I make the following statement in regard to the detention of vessels at the canal. When a number of tows are coming down at the same time, some of them have to round to, and wait for the first to get through. When a tow is going up through the canal and tows are coming down, the downward-bound tows have to round to, causing much detention. In a beam-wind while in the canal, vessels often sheer so as to strike one side of the bank of the canal, while the tug which is hauling them is on the other.

In a strong beam-wind they are obliged to break up their tows and take a part of the tows through at a time. There have been several cases in entering the canal from above in which the sheer of the vessel caused them to strike the dikes at the head of the canal, damaging both the dikes and the vessels. And it became necessary to drive heavy piles and bind them with heavy chains to avoid danger in future.

A raft came down a short time since and was swung by the winds entirely across the head of the canal, blocking it up entirely for twenty-four hours. There have been a number of similar cases before. The same difficulties are liable to occur at any time. When there is a fog tows do not attempt to pass through the canal, but round to and wait until it clears off. The largest class of vessels have taken the old channel on account of drawing more water than there is in the canal, and as the United States Government are now deepening the channel of the canal, no tows pass through at the present time.

W. H. MOTT,
Custodian of the St. Clair Flats Canal.

ANSWERS TO QUESTIONS.

1st. How many vessels have passed Fort Wayne, both ascending and descending, during the season of navigation, annually, in the last six years?

Answer. We have not the actual count. Our estimate is from 125 to 150 per day.

2d. What was the tonnage-amount of these vessels for each year?

Answer. The tonnage of vessels for 1872 was 609,787 tons.

3d. What is the height of the top of the topmast of the largest of these vessels above the surface of the water, and the height of the top of the mainmast?

Answer. One hundred and seventy-two feet to the top of the topmast, and 106 feet to the top of the mainmast.

4th. Please furnish me with a list of about twenty or thirty of the vessels which have the highest masts, with the height of the latter in each case, and the height of the top of the mainmast above water, and the same, and the tonnage of each?

Answer. Schooner A. B. Moore, mainmast 101 feet, topmast 174 feet, 1,099 tons; schooner Emma C. Hutchins, mainmast 106 feet, topmast 177 feet, 736 tons; schooner Nelly Redington, mainmast 106 feet, topmast 172 feet, 817 tons; schooner Scotia, mainmast 105 feet, topmast 164 feet, 904 tons; schooner B. F. Bruce, 671 tons; schooner Bridgewater, 706 tons; schooner Alva Bradley, 649 tons; schooner City of Painsville, 601 tons; schooner W. S. Crosthwaite, 671 tons; schooner F. L. Danforth, 715 tons; schooner S. H. Foster, 720 tons; schooner Helvetia, 793 tons; bark Homer, 513 tons; bark J. S. Mastin, 620 tons; schooner Marengo, 648 tons; schooner Lucerne, 727 tons; schooner E. A. Nicholson, 721 tons; schooner S. S. Osborne, 655 tons; schooner Joseph Page, 625 tons; schooner Pathfinder, 635 tons; schooner Thomas Quayle, 644 tons; schooner Red Wing, 722 tons; schooner Thomas P. Sheldon, 669 tons; schooner Annie Sherwood, 622 tons; schooner Kate Winslow, 733 tons.

The exact height of the masts of the above list of 23 vessels we cannot give, but it is safe to say that the mainmast will average 100 feet or over, and the top of the topmasts 160 feet above the surface of the water.

5th. What is the character of the freight carried by these vessels?

Answer. Grain, flour, lumber, staves, salt, coal, iron-ore, and general merchandise.

6th. What has been the average cost of transportation per ton for one mile of the freight carried by them in the different months?

Answer. On grain from Chicago to Buffalo, in 1872: April, 2.54 mills; May, 1.66 mills; June, 2.10 mills; July, 2.45 mills; August, 2.54 mills; September, 2.94 mills; October, 5 mills; November, 3.53 mills. Average through the season, 2.74 mills, or for the entire season, \$2.33 per ton from Chicago to Buffalo.

What would be the average delay caused to each vessel in the following cases, viz:

6-1. In case of a bridge with 400 feet spans, 135 feet high, and the same bridge with 800-foot spans?

Answer. Twelve hours each time they go under the bridge. This, we think, much below the time the large vessels would be delayed, but taking into account the small vessels that would not have to lower the topmast, we estimate twelve hours as the average delay. This estimate is based on time occupied in preparing to go through and putting gear in place after getting through—not estimating the delays caused by collisions with the piers, which, we think, would be at least one every day; and that 25 per cent. of the collisions would sink the vessels. The delay in case of the 800-foot spans would be the same as the 400 feet, from the fact that the estimate is based on time occupied in lowering topmast and putting it in place again. But the risk of collision with the piers would be very materially reduced.

6-2. In case of a bridge with 400-foot spans and 100 feet high?

Answer. This case we should estimate the same as in the 400-foot spans and 135 feet high, so far as the vessels could get through at all, many of the large vessels having 100 feet or over mainmasts, besides a much larger number that could not get through with their topmasts up; these would in case of a bridge 135 feet high. We think it would be quite low enough to estimate this delay at *fifteen hours* each time of passing the bridge.

6-3. In case of a bridge with three pivot-draws, with six openings, each being 160 feet in the clear, and also in case of the same bridge with two pivot-draws and four spans?

Answer. In this case of course no lowering of the topmasts; but the draw being only 160 feet wide it would involve the necessity of breaking up the tows and taking each vessel through separately, which of itself would take considerable time; and some part of the time vessels would have to come to anchor above and below the draw before the tow would be prepared to move on. We think four hours per vessel each time of passing the draw would be a low estimate, and this for *one bridge only*. To give permission to build one bridge means *four bridges*, to wit, *one at Detroit, one at St. Clair, one at Port Huron, and one at Malden*, making a detention of sixteen hours each time a vessel passes through the river.

6-4. In case of a low bridge with two spans 400 feet in the clear removed during the season of navigation, leaving a bare pier not more than 25 feet high, and a draw near the American shore with two openings each 100 feet in the clear?

Answer. We think two hours' detention would be a just estimate. We make the detention in this case less than the three pivot-draws of 160 feet spans. From the fact that more tows will go through without breaking up, we estimate the detention in this case one-half of what it would be with three pivot-draws. In case of 6-1, allowing

that the lowering of the topmast would be done but once during the passage of the river on data of twelve hours' detention, the loss to vessel-owners in one season would be \$1,516,000; to add to this would be a large amount for damage caused by vessels colliding with the bridge, and with each other.

7th. What would be the total loss to the whole navigation produced by this delay in each of the cases mentioned above; and upon what data are your estimates based?

Answer. In case of the 160-foot-draw bridge on the lowest estimate of the number of vessels, 125 per day, and detention of *four hours each at each bridge*, the daily loss in time would be twenty-one days each, twenty-four hours for *one bridge* only, or 50.40 days in the season, which, at the estimate of \$100 per day, would be \$504,000 for the season. This estimate of \$100 per day is low; and to give you some data to judge by we would say the daily expense of most of the steamers is \$140, and of moderate size and large sail-vessels \$100 per day, making our estimate of \$100 per day within the actual value of the time alone in passing the *four bridges* \$2,016,000, to say nothing of the large amount that would be required to pay damages caused by colliding with the bridge and each other in the process of getting through the draws, which of itself would amount to millions of dollars. In addition to the estimated loss of \$2,016,000, we believe it would not be an unusual thing for the large class of vessels in colliding with the bridge to sink themselves and throw the bridge off the abutments into the river, causing great detention both to vessels and to railroad-trains.

8th. What number of each of the following classes of vessels pass and repass Fort Wayne:

8-1. Vessels with masts and without steam-power?

Answer. Ninety-five daily.

8-2. Vessels with masts and with steam-power?

Answer. Thirty daily.

8-3. Without masts and without steam-power?

Answer. One-half of one per cent. of all.

9th. What is the aggregate tonnage of each of these classes of vessels for each of the last six years?

Answer. For 1872, sail-vessels, 338,924 tons; steam-vessels, 136,863 tons; new vessels, sail and steam, 134,000 tons—aggregate 609,787 tons; average tonnage of sail and steam craft 277 tons each.

10th. What is the total amount of freight carried by each class past Fort Wayne annually during the last six years?

Answer. The amount of freight is about equally divided among the sail and steam craft in proportion to their capacity, except the general merchandise is mostly carried by the steamers, and coal and salt on sail-vessels. The total commerce of the Detroit River for 1872 was 9,116,570 tons.

11th. What is the value of the freights carried in each of these classes of vessels annually during the last six years?

Answer. We have no means of determining the proportion of value of freights carried by sail and steam vessels, but we think it safe to say that the total value is \$500,000,000.

12th. What is the value of these vessels?

Answer. Thirty-six million seven hundred and sixty-five thousand dollars. The data for the valuation is the underwriter's valuation, with 25 per cent. added. This estimate will come below the true value, as we have verified by many cases within our personal knowledge.

13th. How many of them carry passengers?

Answer. Ten per cent. of all steam-vessels.

14th. What is the number of passengers?

Answer. We have no means of ascertaining.

15th. What is the number which are towed, and what is the number of tows?

Answer. Seventy-five per cent. are towed.

16th. What percentage of those towed number eight vessels in a tow or more?

Answer. One-tenth.

17th. Please furnish the estimate of cost of special apparatus for lowering top-masts, and the time and cost of one such lowering and raising with the apparatus in passing the bridge for a three-masted schooner of 1,000 tons.

Answer. We have applied to ship-builders for an estimate of the cost of such apparatus, but as yet have not been able to obtain it.

18th. Please furnish us with any information which, in your judgment, will have any bearing on the questions before us.

Permit us to call your attention to some considerations which, we think, have an important bearing on the policy of bridging the Detroit River:

1st. The increase of tonnage of vessels navigating the river and lakes is 20 per cent. annually, and there is every reason to believe it will increase in the same ratio for the next decade. This increase is quite equal to if not greater than the increase of railroads in Michigan or the Western States.

2d. For long distances produce and merchandise can be carried by water at far less cost than by rail. For instance, some of our largest vessels will carry 60,000 bushels of wheat from Chicago to Buffalo. To transport the same quantity by railroad would take 9 trains of 20 cars each, or 9 engines and 180 cars; the cost of the vessel and equipments, \$75,000 to \$80,000. Nine engines and 180 grain-cars would cost not less than \$225,000, to say nothing of cost of building the railroad, culverts, bridges, station-houses, &c. Then the engines and cars wear out three times as fast as vessels. We think it a self-evident proposition that any obstruction to the river and lake navigation will increase the cost of transporting the products of the great West to the Eastern States and the seaboard. The policy of bridging the Detroit River, we suppose, depends upon the answer to a single question: Will it be a general benefit to the whole people of this country? If bridging the river will give cheaper transportation, and thereby better reward the toil of the farmer, the miner, and mechanic, then the bridging should be allowed. But if the producers will be injured for the benefit of the middlemen—the carriers—then it should not be allowed, though demanded by all the wealthy corporations in the country.

The General Government has expended some half a million dollars to remove the natural obstructions to our river navigation. This removal of obstruction by constructing the St. Clair Flats Canal is of immense benefit to navigation and the whole people. Now it is proposed to place artificial obstructions, not below the water, but above it. We consider it by no means certain but that the latter obstruction would be quite as serious as the former was.

Individuals of moderate capital can build and equip a vessel and enter the market in the carrying-trade as a competitor with other vessel-owners and railroads. When freight is scarce this competition carries the price down to the lowest point. For instance, last May grain was carried from Chicago to Buffalo for 1.66 mills per ton for one mile, or \$1.32 per ton from Chicago to Buffalo. The owners of vessels are so numerous, they are scattered so widely apart from Lake Ontario to Lake Superior, and their interests are so varied, that any consolidation or general combination is an impossibility.

The reverse of all this is true in regard to railroads. It requires large and associated capital to build and equip railroads, and when built they are often under the control of one man, or, at best, a very few.

There is not and cannot be competition and individual enterprise among the owners (stockholders) as there is between vessel-owners. Even where there are competing lines of railroads, mutual interests lead to consolidation, and competition is at an end. We hazard nothing in saying that the only competition that is really worth anything to the producers of this country against railroad monopoly and high freights is water transportation.

It is a well-known fact to all experts and men engaged in crossing the river during the winter months that railroad facilities are entirely inadequate and unfit for the work they attempt to perform. They are a long way behind in the construction and capabilities of their boats now in use to perform the work, as compared with modern-built boats. To bear me out in this statement, I call your attention to the ferry-steamers Victoria, built and equipped by one of our oldest and most efficient ferryman, Captain Clinton. She is but 192 tons burden; was completed and put on the ferry in December, 1872; and though last winter was the most severe within the recollection of that most familiar veteran, the oldest inhabitant, yet I am told by her captain that in no case during last winter was she longer than 15 minutes in crossing the river, unless the detention was from other causes than ice.

It is plain to be seen that if a vessel of the size of the Victoria can cross the river in the coldest weather (such as we had last winter) in 15 minutes, a vessel of a thousand tons burden, built in a first-class manner, would find no difficulty in crossing in a much shorter time. I claim, without fear of intelligent contradiction, that four such steamers could promptly carry all freight and passengers that the Great Western and Michigan Central Railroads could bring to the river in coldest weather, and in moderate weather two of them could do it all.

It is a well-known fact that weather severe enough to bridge the Detroit River with ice reduces the capacity of the railroads in transporting freight about one-half.

During the severe weather of last winter all railroads having no rivers to cross in about this latitude were delayed in their freight transit nearly as much as was the Great Western and Michigan Central Railroads.

I will state here that where the steamer Victoria crosses the river so successfully is at right angles with the current; that is to say, one landing is directly opposite the other, so that no time is lost or expense incurred which the railway ferries are subject to by starting down stream and landing up stream, thereby doubling the distance by crossing the river diagonally.

I think I am correct in saying it was the original intention of the Great Western Railway to cross the river at right angles from the Michigan Central depot, as they

procured the right of way along the river shore, and drove piles for a railroad track to a point directly opposite said Central depot.

Boats for taking cars across the river should be built double-enders, and cross the river on the shortest line. Especially should they cross in this manner during cold weather. Then by frequent passage the river would be kept open at the point of crossing, and neither freight nor passenger trains would be much delayed, and in no winter need there be any partial delay over a period not exceeding twenty-five days in each month. Both these roads, I believe, have the necessary ground to make suitable slips to receive the double-enders, and thereby save the trouble of turning round in the ice, as is now done by all the ferries. One million dollars would build and equip these four boats.

It is claimed that there is a large number of boats pass the Chicago bridges without trouble; this is the fact; these vessels passing the Chicago bridges are in a good harbor where winds cannot affect them as in an open roadstead; their canvas is all in, their anchors on board; but most of these vessels are moved with two tugs, one at the bow and one at the stern, and this at an average cost of fifty dollars for each vessel. I think boats can be built that will transport the freight across the river at Detroit for the interest on the cost of a bridge and the cost of managing it, and at an average delay of no more time than would be caused by the opening of the draws in the bridge for the passage of vessels, understanding, of course, that vessels have the preference in passing the draw as against freight-trains.

G. W. BISSELL,
ROBT. J. HACKETT,
Committee.

MEMORIAL FROM DETROIT AGAINST OBSTRUCTING LAKE-NAVIGATION BY BRIDGING
DETROIT RIVER, AND FACTS TOUCHING THE SAME.

To the Legislature of Michigan, in Senate and House :

The undersigned, residents of Detroit and mostly persons engaged in business, respectfully but earnestly ask that you take no action indorsing or encouraging the building of a railroad-bridge across Detroit River, here or at any point, and we offer the following as some of our reasons for this request :

First. Such a bridge would not relieve or expedite the business of railroad, while it would be a serious hinderance to the much larger business of the great shipping-interest of the lakes, and thus raise the cost of transportation, to the injury of the people. In round numbers, the 2,500 vessels on the lakes pass any given point on the river (Detroit for instance) 33,000 times during seven and a half months, averaging one vessel each ten minutes, night and day; and sometimes this average is once in five minutes, with successions of tows of four to eight vessels, which would prevent a draw-bridge being closed for hours, and of course prevent meanwhile the passage of all cars. We leave it to your judgment to see of what use a railroad-bridge thus constantly obstructed could be. It is also impossible for a long tow of vessels to control its motions so accurately as to pass a draw without danger of accident.

Second. Even if a tunnel beneath the river is abandoned, (for which there is no good reason, as the late statement of the superintendent herewith offered shows,) powerful ferry-boats will serve the railroad better than a bridge. The International is an iron ferry-boat used at Port Huron by the Grand Trunk Railroad, and has made frequent trips across the river and back in twenty minutes, carrying twenty-one loaded freight-cars, and its yearly expenses are but \$20,000. Allow one hour for each trip, and this boat could transfer across the river at Detroit four hundred cars each twenty-four hours, and three such boats would transfer twelve hundred cars per day, at a total cost of not over \$100,000 per year, while the mere interest on the cost of a bridge, not counting wear and damage, would be over \$200,000. Responsible parties in our city are ready to contract to transfer all cars, &c., at less than the interest and wear of the proposed bridge.

During the past winter the ferry-boats here have actually carried across the river all cars offered from this side, and any hinderances suffered have been caused by the inability of the Great Western Railroad of Canada to send east, from the Canadian side of the river, the freight sent them; and this inability compelled the Michigan Central Railroad to lend this Canadian road some twelve or more locomotives to help carry off its accumulated freights. At Toledo, where the Maumee River is bridged, we hear of cars waiting for weeks to go east; so that granting hinderances here, they are there also during the past winter.

Third. The ice is not a barrier to rapid passage of boats five months in the year, as has been stated, but not over an average of forty days, for a term of years.

Fourth. Far more freight is carried by water than by rail, and at lower rates. From Milwaukee, in 1872, while 13,000,000 bushels of wheat and 700,000 barrels of flour were forwarded by water, only 326,000 bushels of wheat and 490,000 barrels of flour were sent by rail, and from Chicago the proportions are nearly the same. As to comparative prices, we would ask if railroads will carry freight in the winter at the same rates they do in summer, when compelled to meet the competition of vessels? We apprehend they would hasten to abandon both bridge and tunnel rather than make such agreement.

We would also suggest that when railroads will transport the grain and flour of Michigan farmers from the interior to Detroit as low even as they do the products of Illinois farmers from Chicago, a proposal to build a bridge across our river, to the hinderance of navigation, would come with better grace than now. For instance, the freight on flour from Marshall to Detroit is 34 cents per barrel, while through-freight from Chicago, treble the distance, is but 30 cents, now that no lake competition is to be met.

These are some reasons, among many, why we believe our request to be just, for the public good, and not injurious to the railroad interest, which we wish to prosper, *but not at the expense of the larger shipping interest or of the people.* We would also suggest that the thousands of vessel-owners for whom we address you are scattered along the lakes, in many harbors and ports, while the railroad management is concentrated in a few hands, ready to act at once and to gain a hearing easily.

Merrick, Fowler & Esseltyn.	F. L. Lasier.	F. A. Hussey.
Robert J. Hackett.	T. J. Perry.	Funda, Esselstyn & Co.
P. J. Ralph & Co.	A. Morrison.	Livingstone & Co.
Geo. McMillan.	D. R. Pierce.	Fenton, McWilliams & Co.
James M. Ballantine & Co.	O. P. Lewis.	John Monaghan.
H. Moffat.	D. C. Spaulding.	John R. Gillett.
F. Buhl, Newland & Co.	R. O'Connor.	John P. Sullivan.
John Owen.	Thomas Adams.	John W. Thompson.
E. R. Ward.	John Baxter.	D. Carter.
G. F. Bagley.	David Hill.	N. J. Rodier.
A. E. Bissell.	Wm. Cuddy & Co.	Eber Ward.
Brady & Co.	H. Coyne.	E. S. Ketsey.
G. F. Hinchman & Co.	James A. Armstrong.	B. Whitaker.
S. R. Kirby.	George N. Brady.	C. K. Dixon.
D. V. Bell.	J. M. Nicol.	J. Pridgeon.
C. Van Husen.	Chas. Chamberlain.	J. Demass.
A. R. & M. F. Linn.	G. W. McGregor.	H. Estell.
Geo. E. Curtis & Co.	C. C. Blodgett.	S. Longston.
Cornwells, Price & Co.	Miles Joy.	I. Ibbotson.
Hitchcock, Esseltyn & Co.	Joseph Cook.	John Oades.
Darius Cole.	Henry Hackett.	E. Mayes.
Ira F. Holt.	Peter J. Ralph.	J. Hoffner.
Jno. Babillion.	D. D. Roberston.	R. Cusou.
Evans & Walker.	N. L. Montgomery.	J. Harvey.
R. H. Anderson.	James E. Pittman.	Dunlay, Donaldson & Co.
Preston Brady.	Wm. Smith.	S. R. Kirby.
C. R. Bagg.	Wm. Phelps.	Croul Brothers.
A. G. Lindsay.	James Findlater.	C. Hurlbut.
T. E. Daniels & Co.	James T. Campbell.	John Hosmer.
E. W. Moore.	Mowry & Co.	George Wilks.
J. S. Craig.	L. J. Staples & Co.	James M. Beck.
P. Young.	S. Ferguson & Co.	Robert Holmes.
C. H. Moore.	G. S. Wormer & Son.	H. Coyne.
Geo. C. Langdon.	Geo. B. Kelley & Co.	Wm. Clay.
D. J. Clark.	John Demass.	G. W. Bissell.
L. B. Austin.	W. H. Chelvers.	D. Carter.
W. H. Brace.	H. Smith.	E. R. Viger.
O. Staples.	P. B. Thompson.	Wm. McKay.
George Newberry.	Geo. F. Thompson.	F. Lambie.
Moses Duncan.	Geo. Ramsdell.	Linn & Craig, Gibraltar.
S. B. Grummond.	Geo. E. McCulley.	A. P. Toulmin.
Jos. Nicholson.	H. W. Colman.	David Gallagher.
J. N. Dean.	M. H. Brooks.	W. R. Dodsley.
C. H. Dickerson.	S. R. Thompson.	N. Gonyau.
J. B. Bloss.	John Kent.	Wm. Richtenberg.
G. T. Eames.	Timothy Moynaham.	O. C. Wood.

FACTS ON SHIPPING ON THE LAKES.

DETROIT, March 13, 1873.

Memoranda from the books of the United States supervising engineer of steamboats for the eighth district.

There have been inspected in the eighth district, in 1872, 413 steamers of all classes, a total of 73,156 tons, with 1,524 masters, mates, pilots, and engineers, licensed, and they carried, last season, 1,146,343 passengers; the eighth district comprising Lakes Huron, Superior, and Michigan, trading through the Detroit River. In the ninth district, comprising Buffalo, is about the same ratio as the eighth.

PETER J. RALPH,
United States Supervising Inspector of Steamboats, Eighth District.

Tonnage in eighth district has more large iron steamers which pass Detroit River to Lakes Michigan, Huron, and Superior. In thirty trips one of these boats would bring up or down Detroit River 40,000 tons of freight in a season, equal to 140 trains of 25 loaded cars each. A single large sailing-vessel, of which there are many, will make eight trips, carrying 50,000 bushels wheat one way and 1,000 tons coal or iron-ore the other, equal to 65 trains of 25 loaded cars each, for the freight of a single vessel for a season.

In addition to the vast quantities of wheat and flour freighted down the lakes at lower rates than by rail, from seven hundred thousand to a million tons of iron-ore will pass down Detroit River from Lake Superior the coming season, and the hinderance of a bridge would tend to increase costs and enhance the cost of iron to the consumer.

THE TUNNEL—AN INTERNAL AND TECHNICAL HISTORY OF ITS CONSTRUCTION—WHY WORK WAS STOPPED—NO REASON IN THE NATURE OF THINGS WHY IT SHOULD NOT GO ON.

To the Editor of the Detroit Post:

I have frequently seen in your paper accounts of the impracticability of building a tunnel under the Detroit River because of the bad ground and length of time required to put it through. Having had the honor of starting this work, being superintendent, first, for the contractors, and latterly for the tunnel company, I should know more about the ground than those who have based their opinions upon mere hearsay. One of the statements was, that the ground is too bad. That is entirely wrong, for the ground through which the main tunnel was intended to be constructed is about the best ground in which a tunnel was ever projected. It is much better than any person connected with the work expected to find, being a very tough blue clay. Other statements were that the large tunnels would cost over and above the estimate, in the same proportion that the small one has cost above its original estimate. That is not right, for several reasons: When the estimate for the work was made it was the opinion of all parties concerned that the blue clay extended down below the bottom of the proposed drainage-tunnel, which, bear in mind, is entirely below the large tunnels. The boring-tools that were used were not of sufficient strength to test the ground below the main tunnel. The cost of the drainage-tunnel was the only doubtful estimate, and for that reason it was started first. If it had turned out as represented, that is, had it been blue clay, we should have made 18 feet per day; but when the shaft on this side was sunk down to the level of the drainage-tunnel, we found the ground hardpan instead of blue clay, and instead of 18 feet per day, could only drive 4 feet. Now the company knew before we started that it would take at least four times as long to put the drainage-tunnel through as had been expected; and being so close to the bed-rock, it was also liable to strike water, which would add very materially to the cost of the work. There were then left them three or four different ways to save time and money; one way would have been to sink one or more shafts in the river so as to have so many more faces to work from. Another was to have started the main tunnels, and carried along the bottom-drift with it, which would have lessened the cost of the small drift at least 100 per cent., for the reason that the same machinery that was required and used in working the small drift would have done for the rest at about the same cost. The company may claim that they wanted to prospect the ground before starting the large tunnel. Why, then, did they not begin on the main work, and run a heading through the large tunnels, where they could have made nearly five feet to every foot in the drainage-tunnel, and thereby have saved four-fifths of the time? But instead of that, before we were at work two months, the report came that the tunnel was going to cost too much money, and would be stopped. From that time to this it

has been the report from week to week. I, for one, could not work with the energy and will required in order to put through an undertaking, such as it was, knowing there was no spirit where the money came from, and that our work was liable to be thrown away next day. We pegged away, however, until we reached a point 1,229 feet from the shaft, when we struck a spring of sulphur-water, which, with what we had struck previously, made 120 gallons per minute, requiring more powerful machinery than we had in use. On this account we waited until the Canada side had invested as much money as the Americans had done. The Canada shaft was sunk in about thirty days. In sinking it it passed through identically the same strata of clay that it did on the American side. But between the hard-pan and blue clay lay a thin vein of sand. We drifted in here something over 200 feet, when we struck a small spring of water (not any more than would pass through a two-inch pipe) which came to us through this vein of sand. It carried considerable sand into the tunnel with it. The drift was so small only one man at a time could work to shovel it, and while it was running no other work could be done, for want of room. The sand that lay nearest to us would run out, then the blue clay (which is over 70 feet thick) would swell down and shut off both sand and water. We drifted ahead until we came to ground that had not swollen, and then got our spring again. We ran along with it in this way for over 150 feet. In advancing this 150 feet the water broke out, and clay shut it off again about twelve different times. We always found that the same quantity of water came each time, neither increasing nor decreasing. We wasted all summer and fall in this work, being compelled to work at it with one face at a time, though knowing that if we had another drift alongside of this one the water and sand, while moving into the one would leave the other dry and workable. It was months after this plan was proposed before any action was taken on it. However, on or about the 14th of December, permission was given to start the second drift immediately above the first, in the stratum of blue clay. We ran that drift 289 feet in thirteen days; 22½ feet per day; whereas in the first drift, down in the hard-pan, it took us nearly six months to go that distance. We had then passed over some portion of the ground under which the sand had been taken. We ran through this section without any sign of sand or water until we reached a point 454 feet from the place of starting, which brought us 50 feet ahead of where we left the first drift. At this point our spring of water came in, but stopped running in the old one. We then pushed the old one ahead 50 feet, let the water in there, changed back to the new drift, and ran it ahead 20 feet farther, when orders came to stop work. Such are the difficulties that have, it seems to me, put a stop to the Detroit River tunnel. Why, a gang of gold-prospect miners, a part of them working for wages while the rest were fighting obstacles, would laugh at the idea of stopping a drift for the sake of a two-inch stream of water.

Again, the company claim that they can build a bridge in less time than the tunnel can be built. Let them start in with the same determination to build the tunnel that they have the bridge, and, in my opinion, the tunnel will come out first every time. Let them sink a shaft every 800 feet and work both ways from each shaft. It would then be only a question of how long it would take one gang of men to build 400 feet of the tunnel. If one gang of men can build 400 feet of tunnel in one summer, why cannot twenty gangs of men build 8,000 feet in one summer? Perhaps they think the shafts too expensive. To have one every 800 feet would require (besides the two they have now down) four on the land and three in the river. The land-shafts will cost less than \$8,000 apiece—the river-shafts considerably less than \$100,000 apiece. The shaft now down on the American side was put down in 22 feet of water, and cost \$20,000. Those required in the river would be in the water 30 feet, one on each side of deep channel. Let them offer that price to put them all down in six months, and see how quickly they will find men to put them down for the money. The shafts in the river should be set between the two main channels, and as soon as the tunnel is completed be torn out again. My reason for writing the above is to try and correct any impression that this tunnel was abandoned on account of lack of skill to overcome the difficulties met with there, and to show that a tunnel can be built in less time than a bridge. Those who come hereafter and build this tunnel will wonder what obstacle stood in the way. I have put in too many hard knocks and long hours on this tunnel to see it thrown aside in this way, without expressing my regret.

Lack of energy and faith on the part of those who hold the purse leave the tunnel not yet commenced, whereas otherwise it might have been nearly completed.

D. D. McBEAN,
Superintendent of the Tunnel-Works.

III.—STATEMENT OF MR. FRANKLIN MOORE.

I have resided in Detroit nearly forty years. My business during that time has been mercantile principally. I am now engaged more in the lumbering business than anything else, and tugging and running logs down the river. I am interested individually

in bringing to market, towing, and sawing about twenty-five million logs a year, a great majority of which I tow down through this river to Ohio. In towing these logs we use our own tugs. This year we have employed two; we do a little tugging outside for others. I have been more or less engaged in the lumber business for the last twenty years; largely for the past six. I ought to be pretty well acquainted with the commerce that passes up and down the river. I have been at it always, furnishing vessels, and with them, and using them, &c. The principal items of commerce on the river are minerals, lumber, and grain; some considerable salt of course. The other articles are the three principal ones. Of late years it has been the habit of transporting altogether more in barges; lumber principally. The great majority is transported either in barges drawn by tugs, or one barge will tow itself and draw two others; it is all the same thing. This mode of transportation has been increasing every year up to this year. Almost all the transportation through the river from one lake to the other is effected by tugs. There is hardly anything of any kind that is not drawn so. It is a very rare exception that a sail-vessel goes through without being drawn by a tug.

There is considerable more commerce above Detroit than there is below. There is a great deal done at Port Edward. Now that they have got a loan of \$20,000,000 from England for the Grand Trunk Railroad, they are going to put it in trim, and it is going to be more important than ever. There is an immense amount of commerce passes around by Saginaw to Milwaukee and Chicago. I could not fix the proportion of the general commerce which is above Detroit.

I think, and it is the general opinion, that the completion of the Northern Pacific Road will largely increase the business of the Michigan Road. I think the building of this bridge is one of the most important things for our agriculturists of Michigan; more important than any other thing that has been projected in this country.

Navigation often closes early; business all stops; there is a large foreign trade springs up. There is a great demand for our wheat; here it is, but you cannot get it to market; it is all dammed up here and you can't touch it, whereas if we had a good bridge across the river we could market that wheat at a large price. Here in the winter, when we have nothing else to do, it would be a saving of interest and a saving of time, and it would improve the market; whereas without it we are completely stopped up the whole winter. For years and years we have suffered immensely here on account of the ice in the river, even from the first.

The second year after the railroad was built here, there was an immense lot of pork coming forward. They didn't go over the roads on the south shore. They brought the hogs here, great numbers of them. They had to take them in lots, of a hog, or a hog or two at a time, and run them over the river. They had no boats to do anything, and they were all winter getting the hogs across. That was the only way they could get them across at all. That is the way it has been, more or less, ever since. As the business of the country increases the more embarrassed they are. As the business of the road increases it becomes more and more serious. We have had nothing before to compare with last winter. We have had some winters that there was not much ice in the river, but those were rare. Generally there are some two or three months when the river is so full of ice as to seriously impede navigation. Some years, of course, there are more than that. The ice in the river during the winter often breaks up very rapidly. The moment it stops freezing, and a south wind comes up, it will go off, sometimes in a night. From my idea a winter bridge, to be laid out on the ice and taken up, I don't think would be practicable at all. Then there is another thing. There are six months in the year when there are no vessels passing up or down, ice or not. There are only about six or seven months that you want to use vessels. Sometimes, in fact, during the winter, the ice breaks up so rapidly that it could not be depended upon as a foundation for a bridge. The river itself does not freeze clear across, but the water freezes in pieces and becomes wedged together, and so is frozen. Consequently breaking up takes but little time. I have often known the channel nearly free, or the ice floating in pieces in the morning, when in the evening before it appeared to be frozen solid clear across. There is one particular point about it. This river don't freeze across. It is the ice that comes down from above and is clogged here and freezes in pieces.

I do not think myself that a bridge of four draws of 160 feet each would seriously impede navigation. There would be always of course some little delay; but the great interests of this State, ninety-nine hundredths of it, are in favor of it—a railroad crossing the river. I don't myself think the people of this State ought to be deprived of a railroad to accommodate the vessels, when they only run half of the year any way. Even if it should embarrass navigation a little, they have got to put up with something. This great amount of travel must be divided up between the two interests. They cannot have it all. They have got to put up with some slight inconvenience for the sake of the great public interest, not only of this State but of the whole West. A few men cannot have all the benefits of that thing. That is my view of it. If I bring a raft down here I might possibly have to stop here to put on wood, or stop here to get provisions. We do that now very often as it is—half the time. They often stop and round to here, and that is the case with all tows. No matter how many vessels they have

they will stop here for half an hour for provisions; ten times as long as it would take to get through that bridge, very often. Even if they had to wait for one to go through, I don't think anything of that at all. We stop oftentimes going up or down with our raft. We don't so often with a raft as we would with a vessel, for the reason that you cannot handle a raft as well as a vessel. Our business office is right on the water, and very frequently a tug passing by will come up and lie there 20 or 30 minutes with the whole tow until they can go ashore and get provisions. It is no inconvenience, then, and it would be no more, certainly, if we had a bridge. That is my opinion. Tows coming down here, if they stop, are always obliged to turn around on account of the current. I should think a bridge, 16 miles below, at the Canada Southern, with two draws of 160 feet, would be as effective as one here with four. Of course so near the city, right here in the harbor, four draws would be very convenient. I think with four draws it is almost equal to no bridge at all.

I think the bridging of the Detroit River would be of the greatest public interest. The effect of the blocking up here in winter is of course very bad. Others can tell you more about the delay in grain than I can, but there has been so much said about it, so much fault found with it, that it is hardly necessary to repeat it; but it certainly is a very great delay, and a very serious inconvenience to the grain community, and to every community. We must consider the fact that the commerce of the West is constantly increasing, and such being the fact, if we are compelled to rely upon the agencies we have in getting across the river, the conclusion is inevitable in my mind that the commerce coming from the West to the East must necessarily change its passage off around the lakes.

FRANKLIN MOORE.

IV.—STATEMENT OF GEN. R. A. ALGER.

I have resided in Detroit seven years. We are engaged in the business of producing and towing to market long pine timber in rafts. We tow from Au Sable and Saginaw, and the east shore of Lake Huron, to Port Huron, Detroit, Ecorse, Wyandotte, Toledo, Buffalo, Tonawanda, and Sandusky. We produce about thirty million a year of our own, and we tow for other people fifteen or twenty million more, making from forty-five to fifty millions. We own two large tugs, the *Torrent* and the *Vulcan*. We bring down an average of about a million feet to the raft. Our rafts will average from 85 to 100 feet wide and from 1,500 to 2,000 feet long.

I think here I had better make a statement of our position in the bridge matter from the start. When this first bridge was talked of down at the Canada Southern, there were these same men that opposed it, and we went in with the crowd and subscribed \$50 to defeat it by legal measures. Some time afterward, Mr. Moore and myself, in talking of the matter, decided that we had done a wrong thing; that possibly it might inconvenience us a little, (we did not think it would,) but possibly it might, and we were satisfied that to cut off the bridge was going to injure Detroit, to make Detroit a side-station, and anything that embarrasses the railroads would, of course, injure Detroit. I so stated to these parties, and since then we have decidedly been in favor of a bridge. However, I suggested to Mr. Moore that we send to Mr. Hackett, who sails one of our tugs—has sailed tugs for eight years; has worked for us five seasons; a man who has no superior; a man whom we pay \$3,000 a year, nearly twice as much as any other tug-captain gets. We called him here and asked him whether he thought it would embarrass us—a bridge across the river. He says, "No; where the current is straight, as it is here, it would not. It would not be half as much trouble as the Government improvement at St. Clair Flats, because on the upper end of the Government improvement the current divides both ways. There we cannot take the full width of 300 feet. We have to come in on the center." We told him that our own private convictions were that we had no business to resist the building of a bridge. We had made up our mind to it, and thought it would not hurt us materially. He thought we were right. He said, "I don't think it will hurt you at all." That is my judgment about it; and the captain of the *Vulcan* was of the same opinion. He is also a man of experience. He has sailed on these lakes for years. He sailed a tug before the war, and he was in my regiment during the war, and since then has been on tugs all the time. William H. Roils is his name. Since that we have tried to investigate the necessities and wants here, as far as we could, and how much injury it would be to us, and we are satisfied that it would be none at all, if captains used due prudence. Of course if a man goes through a bridge he has got to have his senses about him, and steer for the hole and not against the bridge; but there are many places where men cannot sail with their eyes shut. If they could there would be no need of light-houses or experienced high-priced men.

Captain Hackett says there are places on the river, especially below Detroit, that he

thinks are more difficult now than it would be to go through a bridge. For instance, about the "Limekilns," where they have to steer to get through and pass those hidden rocks and obstructions; and he considers the Government improvement at the flats much more difficult than it would be here, because there, although they have 300 feet, they have to meet in the channel, and they never can go out close to the cribs on account of the wash; but he says they never experience any trouble. He even tows our rafts in there when the current sets both ways. I asked Captain Hackett about his experience of the vessels getting out of line while towing. He says that can be avoided. He says a vessel can be steered out, but a tow of vessels can be kept nearly or quite in line, as there is always a man at the helm to steer. He does not think that 50 feet, with any headway that a tug would give, would be more than any tow would drift or get out of line. Captain Hackett says in his opinion there is but one minute in sixty that there are vessels passing any given point. That is his opinion. That is also my judgment. I don't believe there is half a minute, on an average, in an hour that vessels pass up and down from April 1 to December 1, exclusive of the railroad ferries. Our business has been right here on the dock, where we could look out upon the river all the time; and since this matter came up I have taken no little pains to look into these facts.

Nearly all vessels on the river are towed except such crafts as are themselves propelled by steam. They never sail except in favorable winds, and seldom then. Scarcely ever a craft sailing goes by here, and never except in favorable winds. You seldom see a sail-vessel going from lake to lake, with the exception of light scows, unless towed.

I believe that if a bridge is not built it will very seriously affect the growth and prosperity of Detroit, and will make virtually a side-station of it, and will, of course, injure the State just as far as it blocks up its outlet for supplies. If you send it around by Toledo, you cripple our competing lines and increase the cost of transportation, and that will injure our own railroad interests in the State, and would be a greater injury to the producers than to the consumers, because the producers are the great class. A loss of one, two, or three hundred dollars to a farmer may be more than a loss of thousands to men who operate largely. I am satisfied that were the farmers to understand this issue, the whole State, not only here, but the whole West (as they have to send out so many products during the winter, and do not wish to be confined to any one means of transportation) would rise *en masse* and demand it. We claim that if any person would be injured by this bridge, we, of all others, would be injured most. We think the risk to us, bringing down our rafts, is much greater than that incurred by any vessel. A raft has no means of steering. It is simply towed. It is subject to be drifted one way to the other by the wind, and in any still weather cannot be towed to exceed two miles or two and a half miles an hour, and here with the current not to exceed four miles; and we are satisfied that if that gives a draw of 160 feet, one on either side, so as to leave two, that it would not obstruct us at all. I do not think this bridge, if built, will seriously obstruct the vessel interest, except by way of *competition*; and the country should have the benefit of every means of transportation, both by rail and water, to facilitate and cheapen transportation of its rapidly increasing amounts of produce from the West to the seaboard, and of merchandise in return.

This proposed plan of a temporary winter-bridge I do not think practicable, because with the ice settling and gorging against it, it would be impossible to hold it in line, carried as it would be by the heavy current. Indeed I think it would be a very serious question to keep a railroad-track in line there without ice across the current; the slightest deflection would, of course, throw a train off. I hear also an idea advanced of leaving a gap of four or five hundred feet to be bridged over with a ponton. I look upon that with the same objection. You cannot have such a thing without encountering those large masses of ice in winter. I think a bridge with two draws, one on this side to accommodate those vessels wishing to load at Detroit docks, and the other in the main channel, would obviate all just and serious objections that can be raised against it. I don't think there would be any difficulty in a tow of vessels coming down within, we will say, five or six blocks of the bridge, rounding down and go right down the river. But, with a man of good judgment, of course if there were bridges here, if they were going to round to, they would round to far enough up so as to give them headway in coming down. Our captains both say that in any place where the current is straight a bridge with the 160-foot draws would be no serious obstruction.

We have no interest in any way with any railroads. I never received a dollar from them nor a "pass" in my life. I do not care any more about railroads than I do any other public corporation, but we are looking now to what we consider the interest of the State. We are satisfied from investigation that the producing classes, not of Michigan alone, but of the whole country, demand those bridges as an outlet for these railroads.

R. A. ALGER.

V.—STATEMENT OF MR. R. W. GILLET.

I have resided in Detroit eleven years. My business is flour and grain. I have been engaged in that business eleven years. My business is commission purchasing and selling. It is over two millions and a half in extent yearly. I am well acquainted with the character of commerce on this river. I was in the transportation business here six years, in connection with the flour and grain business—transporting from Buffalo to Chicago. I was agent of a transportation line: the great bulk of the commerce passing up and down the river in grain, timber, farm-produce, generally with different ores, iron-ores and others, and salt.

There has been a decided change in the mode of transportation on the river within a few years. Up to within six years the lumber and the grain were transported almost entirely by sail-vessels and by propellers; and within the last six years there has been a great change, until now the great majority of lumber is transported by barges, either steam-barges themselves or barges in tow of steam-barges, so that the amount of lumber is largely transported by steam. Navigation is almost universally effected by tugs, but occasionally, from a local port, a small craft might sail up and down here; but a vessel coming through here by sail, that is to say from Lake Erie to Lake Huron, is a novelty.

I should not think, with a tug going fast enough to keep steerage-way, there would be any danger of their getting out of line, so as to make it difficult or impracticable to pass through a draw of 160 feet. I never saw any such thing. I never have seen them out of line to any extent, so as to embarrass their passing through a draw of 160 feet. I don't think I have ever even seen them out of line 20 or 30 feet. I should say that fully one-half of all the tugs passing up and down the river here stop at Detroit for supplies. When they stop here they are obliged to turn around on account of the current. If they are going to stop at a wharf, they round to—stop with the stern up stream.

I am not prepared to answer with regard to the commerce above Detroit being larger than that below. There is a very large commerce leaving the Lake Michigan ports that goes to Lake Superior; goes to Saginaw and other Lake Huron ports. There is a very large commerce that leaves Saginaw and other points on Lake Huron that is bound for Chicago that never comes through Detroit River at all. There is a very large amount of commerce that goes to Point Edward. There is a daily line of propellers leave there that never come through Detroit River.

There is a daily line of steamers running from Chicago to the Grand Trunk cars at Sarnia—first-class steamers. The term "lake commerce" would include a large amount that never comes through the Detroit River.

We have here, now being built and already built, eight lines of railroad, and I look upon four of these as being yet in their infancy. They have not, either one of them, reached their farther terminus yet. Such being the case, if we are troubled to-day to get our transportation across the river, there will be an absolute blockade in twelve months at the rate business increases. I have had some little experience about detention on the river, this last winter particularly. I have been here in this business eleven years, and I have never seen a year that we haven't been seriously detained. Last winter I was buying grain in Illinois, and I sold a large amount of that corn to distillers across the river—not to go on the Great Western—so the transportation over that road had nothing to do with it; that grain was delivered to the Michigan Central, and was taken over as fast as it could be.

At one time I had fifty cars over there, and on account of the detention by the ice I could not get them back. I went over twice with the superintendent of the railroad to get those empty cars back here. We had forty-odd cars lying there at a detention of over sixteen days on the average. We had twenty cars lying there at an average of over twenty-three days. All it was necessary to do was to get them back here, but they could not be got back on account of the ice. They were not bound east or west, simply waiting to come back here, and the railroad suffered for want of cars. The agent of the Great Western Railroad at one time told me that he had 600 empty cars there waiting to go west, but they could not move on account of the ice. More or less every month of the winter-months the passage of steamers across the river is seriously impeded by the ice. There were two different times this winter when there was a delay of from two to five days, simply from the breaking of the slip. I had grain lie there five days, loaded at the Milwaukee slip. These railroads, diverging from Detroit all over the State of Michigan, all over Northern Indiana, and roads which will connect with the Northern Pacific Railroad, all come down through this one channel; and if they are troubled now with limited facilities for transportation, when they are fully developed they have either got to go across here with all necessary speed, or they will be compelled to go around; that is all there is about it.

The river is never stopped up with ice made in the river. It is ordinarily that which comes down from the lake, floats down here, and stops here, so that it is in masses and freezes together; then by a strong wind of a day or two it is liable to be broken up.

There are days at a time when this river is frozen over, and the boats are three or four hours in passage, when it is ice not made in the river, but simply masses that have floated down; and it would be impossible to sustain a bridge on these masses of ice. We see here every winter, for days, when it is simply a block of masses of ice headed up the lake, and breaking all up in one day.

I cannot see how bridging the river as proposed should be any detention to steam-navigation whatever; I cannot see how there should be any detention to sail-navigation, unless there should be some accident to the bridge, which would temporarily disable it, which would force them to round to. In case they had to stop on account of the bridge, they would be obliged to round to; but we have sufficient way to round to anywhere here for two miles up and down the river. For vessels coming from below there would be no trouble of that kind, for the current would keep them in position. They would simply have to hold on until they got through. I think the detention would be very little, if any, provided you have four openings of 160 feet each; because, even if there are tows going up and down at the same time, those going up can take one side of the river, and those going down the other.

With a bridge down below, where the Canada Southern proposes to build, there would be no necessity of as many draws as here. I think two openings there would be sufficient.

Of course there would be some trouble in a vessel rounding to there, because the channel is not so wide. I think there would be no serious detriment to navigation by having a bridge there.

I always understood, while I was connected with the transportation business, that the channel near the Lime-kilns, about Malden, was only 90 feet wide in places, and steamers often get on the rocks there.

I have not had much occasion to observe the operation and effect of vessels passing through the Government improvement in Lake St. Clair, but from the fact that there the current draws both ways, although there is an opening of 300 feet, in my opinion it would be very much more difficult to enter that canal coming down the river than it would be to go through a draw here.

I think that railroad transportation from the West to the East is far behind the growth of the country; that we need all sorts of facilities in addition to what we have now, and I think that a bridge is of vital importance to the farmers and the producing interests of Michigan and the States tributary to it.

I think that the further building of railroads to Detroit, or the further development of railroads tending to Detroit, is labor thrown away without a bridge.

B. W. GILLET.

VI.—STATEMENT OF CAPT. MICHAEL B. KEAN.

I reside in the city of Detroit, and have resided there and on the St. Clair River forty-one years. My business is owning and running steamers and vessels. I built my first steamboat in 1853, and run her in the lake and river, doing business as master, for several seasons. Have been all the time since 1853 engaged in running tug-boats on the lakes and rivers. Have also run passenger and freight steamers and sail-vessels. During this time I have built, bought, owned, and run, twenty-eight water-craft, six of which were passenger-steamers, ten were tug and freight boats, seven were sail-vessels, and five were barges. I am still engaged in the business, running two tug-boats and four sail-vessels. At the present time and for some years past sail-vessels passing up and down the Detroit River are and have been almost universally towed. From my knowledge of the Detroit River, and the commerce of the lakes, I think it could be bridged without seriously injuring or interfering with its navigation. The river is not subject to floods, and at Detroit there are no side currents to draw a vessel out of its course. I know of no navigable river which is freer from floods and side currents than Detroit River.

A bridge with four draws of 166 feet each, properly regulated and managed, I do not think would substantially discommode or injuriously affect the vessel-interests. In passing up the river, it seems to me that no one who is acquainted with the business of navigation could seriously claim that it would be any inconvenience, if the draws here were properly attended.

In passing down the river in all ordinary weather there would be no serious inconvenience to ordinary navigation, if proper regulations were made for the opening of the draws.

It sometimes happens, especially when there are strong head winds, that vessels in tow get out of line with the tug towing them; this is caused sometimes by bad-steering vessels, or inattention to duty on the part of those in charge, or by the fact that the tug is moving more vessels than she can safely handle in narrow waters; so that she is not able to keep sufficient steerage-way on the vessels in tow. Vessels do sometimes get out of line for the causes just mentioned.

It not unfrequently happens that a tug having a tow coming down the river rounds to and stops at Detroit for supplies, &c.; this "rounding to" ordinarily would delay them from one-half to three-quarters of an hour, depending on the size of tow.

I have noticed the time for several years that navigation is closed, and I think it will average four and a half to five months. During most winters I know it is exceedingly difficult to cross the river with steamers, however strongly built, in consequence of the ice. The shipment of freight by that cause is greatly impeded, and especially when the winter is severe large quantities of freight are blocked up and accumulate on both sides of the river, inducing loss to the common carrier, but a much more severe loss to shippers in additional charges for storage, insurance, loss of interest, &c. I think if a bridge were properly built, so that trains could move at all (or stated) times over the river, it would prevent these large accumulations of freight and should thereby reduce the cost of transportation.

I believe the producing-classes of the Northwest would be greatly benefited by the construction of such a bridge, and that the injury or inconveniences to navigational interests would be trifling in comparison to the public benefit derived. Nothing in my judgment would do as much to keep the carrying-trade within the bounds of moderation as to furnish liberal facilities to both the navigation and railroad interests, thereby creating a wholesome competition between them. Boat and vessel owners exact the highest prices they can obtain for the transportation of freight, and are as exacting in their demands, but no more so, than railroads and other interests. Nothing but fair competition keeps any interest within the bounds of reasonable profits. But aside from the special interests of vessel-owners and railroads, I am fully of the opinion that the general public interests would be largely benefited by the construction of such a bridge over the Detroit River as above stated, and properly regulated and managed.

M. B. KEAR.

SEPTEMBER 13, 1873.

VII.—STATEMENTS OF MESSRS. ALLEN SHELLEN, GEORGE B. DICKENSON, AND DUNCAN STEWART, (J. L. Hurd & Co.)

I have resided in Detroit about eighteen years, and have constantly been engaged in the wholesale dry-goods business. The amount of my sales are nearly \$2,000,000 per year, and my trade is with people of all parts of the State. I have a general acquaintance with the commerce which passes up and down the Detroit River, principal items of which are grains, lumber, iron, and iron-ore. Of late years, much of this is in barges towed by tugs; and I think pretty much all the vessels engaged in commerce, whether sail-vessels or barges, are drawn by tugs. I am not familiar with the amount of commerce between Chicago and other lake-ports and Detroit that does not pass down the river, but from my general observation should think it quite large. In my judgment, a bridge over the Detroit River at Detroit would greatly benefit the producing and consuming classes, as the obstruction by ice during the winter is such as seriously to delay the passage of freight. And I also think a bridge at Trenton, for the passage of freight on the Canada Southern Road, would be equally desirable. Laying aside altogether the vessel and railroad interests, I am entirely satisfied, as a business man, that the interests of the producing classes would be greatly benefited by bridges over the river. With the present serious obstructions from ice to the passage of freight eastward, large quantities of grain and other produce accumulate at Detroit and other lake-ports during every winter. The expense of storage, loss of interest, &c., operates seriously upon the producing classes, so that when navigation opens in the spring they are compelled to ship and pay whatever prices the vessel-owners may demand. If bridges were built and double-track roads, so that the means of marketing would be constantly open to the producers of the West, I have no doubt that the benefits would be immense; indeed it would benefit the consumers as well as the producers in all parts of the country. I have no definite opinion as to the number of months during the winter when the steamers are seriously impeded by the ice, but I should think it would average three or four months each winter.

Without professing to have any special knowledge on the subject, I do not believe, from my observation of the effect of bridges elsewhere, that bridges over the Detroit River, with draws of 160 feet each, would seriously injure the vessel-interest. The river is not subject to floods, and the current is uniform and without side currents. I assume that the bridges will be so arranged that the draws could be opened with facility, and be closed during the season of navigation only during the passage of trains, and that such regulations will be made that neither the vessel nor railroad interest will be seriously incommoded. Then it is to be borne in mind that for nearly half the year navigation is closed. I feel entirely satisfied that unless Detroit River is bridged the freight passing from the West to the East, during the winter months, at all events, will take new channels round the lakes, and that the interests of Michigan and of Detroit will be seri-

ously injured, as her railroads will practically fail to become part of through lines for the transportation of through freight. It seems to me that the agricultural interests of the country demand to be, and should be, fostered, at least by cheap and ready facilities for the marketing of its productions, and that bridging Detroit River would tend to promote this without seriously affecting other interests.

ALLEN SHELDEN.

DETROIT, November 14, 1873.

I have been engaged in the produce business in Detroit for about fifteen years, and am familiar with the movement of grain and general produce from the West to the East. I concur in the general statement above, and am of the most decided opinion that the general interests of the West would be greatly promoted by the construction of a railroad-bridge over the Detroit River at Detroit, and that a bridge could be so constructed as not to interfere with the shipping interest to any extent.

GEO. B. DICKENSON.

DETROIT, November 14, 1873.

I have been a partner of the house of J. L. Hurd & Co. for about twenty-five years. Our business during that time has averaged \$3,000,000 per annum. In 1871 we purchased over sixteen hundred thousand bushels of Michigan winter wheat, for Great Britain, France, and Belgium. Have exported largely at various times Michigan wheat to London and Liverpool; have been, during these twenty-five years, agents and consignors of the Western Transportation Company of Buffalo for a period of ten or twelve years, also consignors at this port of New York Central Road for over ten years, during said period; was also, for a number of years, agent of American Transportation Company; also, for several years, consignor of New York and Erie Railroad Company. Most of these agencies we held at one and the same time. Have also built and owned thirteen propellers, one steamer, and one bark. Our business as commercial men, our business as agents for the above lines, our experience as ship-owners, leave no doubt in our minds of the imperative need of bridges across the Detroit River at Detroit and Trenton, to relieve the fast-increasing production of the West from the grievous delays, disappointments, losses, and damages arising from its present inadequate transportation facilities, and that said bridges, properly constructed, will be no impediment or hindrance to vessels propelled by sail or steam.

DUNCAN STEWART,
For J. L. HURD & CO.

VIII.—STATEMENT OF MR. WILLARD S. POPE, CIVIL ENGINEER, CONCERNING BRIDGING DETROIT RIVER.

The location of the bridge is from the foot of Second street, in the city of Detroit, crossing the river at right angles with the general direction of the current. The distance across the river on this line is 2,650 feet. The surface-speed of the current at ordinary stages of water is about two miles per hour, and is quite uniform across the entire stream. The extreme recorded variation in the water, for a period of thirty years, is about 7 feet; fluctuations, however, of even 2 feet are rare; the surface of water in the summer of 1873, when these surveys were made, was 2.35 feet below the assumed base-line; the variations for a number of years are between 2 below and 4 below. The depth of water varies from 20 to 50 feet, the average being, say, about 33 feet. The immediate river-bed is soft mud, varying from 5 to 30 feet in depth, underlain by a hard tenacious clay. The bed-rock lies quite uniformly at a depth of, say, 83 feet below present water-level. The entire water-way of the stream on this profile is, say, 100,000 square feet. Of the three plans for bridge mentioned below, that marked No. 1 creates the greatest obstruction of the present water-way, the piers occupying an area of, say, 16,000 square feet. To recover the water-way thus usurped, the river must scour its bed between the piers to an average depth of, say, 6½ feet. It is supposed that this will easily be done, inasmuch as the bottom, for a depth of from 5 to 20 feet, is a soft, semi-fluid material through which the sounding-rod descends quite readily; therefore it is presumed that the construction of a bridge on any of the plans mentioned below will not permanently increase the velocity of the current.

Three plans are suggested for bridging the stream, descriptions and drawings of which are herewith submitted, marked, respectively, Nos. 1, 2, and 3.

Plan No. 1 is for a bridge about 12 feet above the water, with fixed spans about 200 feet long, and with two pivot-draw spans so constructed as to allow, when open, four passage-ways 160 feet wide each, in the clear, for vessels.

Plan No. 2 is for a bridge with spans of 400 feet each, in the clear, placed at such an elevation above the water as to give a clear headway under each span of, say, 150 feet.

Plan No. 3 is for a "winter-bridge," which shall have one pivot-draw span, with two clear openings of 100 feet each in clear, permanent, fixed spans of 200 feet each, and two spans of 400 feet each, which shall be moved away during the period of active navigation, say eight months in the year, and used only in the winter-season. Height of bridge above the water, say, 12 feet.

PLAN No. 1.

Low bridge, with two draw-spans—superstructure.

The proposed arrangement of spans is as follows, beginning at the dock-line on the Detroit side of the river; the lengths of span noted in each case being the distance between axes of masonry:

	Feet.
One fixed span.....	100
One pivot-draw span.....	375
Seven fixed spans, 200 feet each.....	1,400
One pivot-draw span.....	37
Two fixed spans, 200 feet each.....	400
Total length of bridge.....	2,650

The draw-spans, when open, will leave a passage-way 160 feet wide, in clear, for vessels on each side of each pivot-pier. The bridge will be for two railroad-tracks, and the superstructure will be, say, 32 feet wide over all. The trusses of the fixed spans will be, say, 28 feet high, while those of the draw-spans will be, say, 28 feet high at the ends and 38 feet high at the centers. From ordinary surface of water to the extreme under side of the superstructure will be, say, 12 feet. Superstructure to be iron throughout.

Superstructure.

Superstructure to consist of two abutments, two pivot-draw piers, two upper and two lower draw-rests, or guard-piers, to receive the ends of the draw-spans when open, and eleven channel-piers, all to be of masonry except the draw-rests. Foundations of all piers to consist of piles driven to practical refusal, and cut off, say, 16 feet under ordinary water-line. Riprap to be deposited between and around the piles, taking its natural slope, and reaching from the river-bed to the tops of the piles. The piles will form the support for a grillage of timber 6 feet thick, on which will be placed the masonry. Thus the bottom of the masonry will be, say, 10 feet below ordinary water-line. Pivot-piers to be circular in horizontal section, and, say, 40 feet in diameter at top, with the usual batter downwards. Channel-piers to be 10 feet wide and 40 feet long at top, with the usual batter downwards except at the up-stream end, which will be provided with a suitable starling or ice-breaker; masonry of piers at bottom, say, 14 feet wide and 60 feet long. Draw-rests, or guard-piers, to consist of timber cribs sunk around piles and filled with and surrounded by riprap. The up-stream ends of the upper guard-piers will be so constructed as to act as an ice-breaker. Between the draw-rests and the pivot-piers will be placed floating cribs of sufficient width and strength to act as fenders to protect the bridge when open, and also as guides to vessels in their passage through the draw-openings. The estimated cost of the bridge built on this plan is as follows:

Substructure.....	\$1,150,000
Superstructure.....	662,000
Approaches.....	25,000
Right of way and land-damages.....	100,000
	2,137,000
Contingencies, say, 15 per cent.....	320,550
	2,457,550

The work of constructing the bridge will occupy, say, a year and a half.

PLAN No 2.

High bridge.—Superstructure of main bridge.

There will be over the river six spans of 420 feet each, and one span of 130 feet measured between centers of masonry, making the entire length of the main bridge 2,650 feet. The bridge will be for two railroad-tracks, and the superstructure will be, say, 50 feet wide over all. The trusses will be, say, 50 feet high. From ordinary surface of water to the extreme under side of the superstructure will be, say, 150 feet. Superstructure will be of iron throughout.

Substructure of main bridge.

Substructure to consist of two land-piers and six channel-piers. Foundations of piers to be the same as described for the piers in plan No. 1, except that the timber grillage will be, say, 8 feet thick. Piers will be of masonry, reaching from the top of the timber grillage, say, 10 feet below the water, to a point 20 feet above water, making a mass of masonry 30 feet high. Masonry at top will be 23 feet wide and 92 feet long, battering as usual downwards on all sides, except at the upper-stream end, which will be provided with a suitable ice-breaker; size of pier at bottom of masonry, say, 28 feet wide and 98 feet long.

On the top of the masonry will be placed a wrought-iron trestle, consisting of ten vertical and four inclined columns, properly braced and tied together; at the top of this trestle will be, say, 6 feet wide, and 52 feet long between centers of exterior columns; and at bottom 17 feet wide and 74 feet long, its height will be, say, 132 feet, making the vertical distance from the surface of the water to the top of the trestle, say, 152 feet.

Approaches.

The main bridge will be reached from each side by a curved approach, constructed with a gradient-rising toward the bridge at the rate, say, of 100 feet per mile. The total length of each of these approaches will be, say, 8,600 feet, of which 1,200 feet at the lower end will be earth embankment, and 5,400 feet will be iron trestle-work, arranged in spans of, say, 30 feet each. The iron trestles will vary from 25 to 150 feet in height.

Cost of the bridge.

The estimated cost of the bridge, if built on this plan, is as follows:

Substructure, main bridge.....	\$2,000,000
Superstructure, main bridge.....	2,430,000
Approaches.....	3,100,000
Right of way and land-damages.....	250,000
	7,780,000
Contingencies, say, 15 per cent.....	1,167,000
	8,947,000

The work of constructing the bridge will occupy, say, three years.

PLAN No. 3.*Winter-bridges.—Superstructure.*

There will be one pivot-draw span 250 feet long, leaving, when open, a passage-way 100 feet wide, in clear, on each side of the pivot-pier; eight permanent fixed spans of 200 feet each, and two movable spans 400 feet each, making a total length of 2,650 feet. The bridge will be for two railroad-tracks, and the superstructure will be, say, 32 feet over all. The trusses will be, say, 28 feet high. From ordinary surface of water to the extreme under side of the superstructure will be, say, 12 feet. Superstructure to be of iron throughout except the temporary movable spans crossing the 400 feet opening, which will be of wood. Each opening of 400 feet will be crossed by two spans of 200 feet each. These spans will be supported where they meet in the center of the opening by a ponton. Just above the ponton will be placed a heavy floating timber crib of such construction and strength and so securely anchored as to afford the ponton protection from the ice. The temporary spans, the pontons, and the floating cribs to be removed from the channel during the season of navigation.

Substructure.

The size, shape, and construction of piers and foundations to be of the same general kind described above, for plan No. 1.

Cost of bridge.

The estimated cost of the bridge, if built on this plan, is as follows:

Substructure.....	\$385,000
Superstructure.....	700,000
Approaches.....	25,000
Right of way and land-damage.....	100,000
	1,710,000
Contingencies, 15 per cent.....	256,500
	1,966,500

The work of constructing the bridge will occupy, say, one and a half years.

WILLARD S. POPE,
Civil Engineer.

DETROIT, August, 1873.

IX.—STATEMENT OF MR. WILLARD S. POPE CONCERNING RELATIVE MERITS OF HIGH AND LOW BRIDGES OVER DETROIT RIVER.

To the Board of Engineers:

Please allow me to present the following considerations regarding the respective merits of a high bridge and a low bridge over the river at Detroit:

It is legitimate to assume that capital invested should receive a fair return in the shape of interest. The only way in which such interest can be derived for capital invested in transportation-facilities is by taxing the goods transported. Assuming the investment to be a judicious one, this tax must always be large enough to cover the fair interest thereon, as well as the current expense of doing the business and of making good the usual and necessary wear and tear. The larger the investment the greater the tax. And this tax falls of course ultimately upon the consumers of the goods transported—that is to say, upon the public. Therefore, any policy or system which increases beyond what is absolutely essential either the first cost of a railroad or its necessary operating expenses, or both, becomes at once a permanent public burden, while any policy or system which diminishes such cost is a public benefit.

Of the plans proposed for the Detroit bridge, two are prominent, viz, one for a low bridge, with two draws, estimated to cost \$2,500,000, and the other for a high bridge, estimated to cost, say, \$9,000,000, a difference of \$6,500,000, the annual interest on which, at 7 per cent., is, say, \$455,000. The former is on a level with the railroads now or hereafter to be built, while, to reach the latter, all trains must forever climb 150 feet. The extra cost of making this ascent may be assumed at, say, \$50,000 annually. Taking the annual expense of repairs and renewal of the trestle-approaches to the high bridge at 5 per cent. on their first cost, (\$3,100,000,) this item will amount to, say, \$155,000. The annual extra cost will therefore be:

Interest on first cost.....	\$455,000
Extra cost of working	50,000
Extra cost of repairs.....	155,000
	660,000

Which, capitalized at 7 per cent., is \$9,430,000.

This amount may be fairly assumed therefore as the real difference in cost between the high and the low bridge, so far as the items above are concerned, and the interest on this amount (\$660,000) the public must annually pay for the luxury of the high bridge over what the low bridge would cost them.

Now, the amount of damage, whatever it may be, to navigation interests, from the presence of the bridge, forms a legitimate charge upon the goods transported by water, and must be paid by the consumers thereof, that is, by the public. Assuming the high bridge to inflict the minimum damage, it may be said that it is of public interest that this form be adopted. But its adoption as shown above entails a permanent and inevitable expense to the public (through the railroad charges) of \$660,000 annually. If a low bridge be adopted, this can be forever saved; against which saving it is fair to offset simply the increased amount of damage to navigation interests from a low bridge over that from a high bridge. If this increased damage should amount to just \$660,000 per year, the two forms of bridge would be exactly on a par, so far as the public interest is concerned. If it should exceed that amount, the high bridge would be an economy. If it should fall short of that amount the low bridge will be an economy.

I have no estimate of the extra damage that navigation interests would sustain from a low bridge over that from a high bridge at Detroit, but to suppose that it would amount annually to \$660,000, or the half or the quarter or the tenth of that sum, seems to me absurd. If this reasoning is correct, it is respectfully submitted that every consideration of public economy dictates the adoption of a low bridge.

In addition to this, the elevation of the bridge (150 feet) is equivalent to removing Detroit one and a half miles away from the railway. All the local business of the city, as connected with the railroad, must be transacted at the foot of the gradient of the approach. Detroit will be located no longer on the main line, but on a branch or spur track; and all the evils will be experienced in perpetuity which are set forth in that part of Mr. Joy's communication to your Board which refers to the location of the bridge at a point near Fort Wayne.

Very respectfully,

WILLARD S. POPE.

DETROIT, November 13, 1873.

X.—PROPOSAL OF MICHIGAN CENTRAL AND CANADA SOUTHERN RAILROAD COMPANIES RELATIVE TO BRIDGE OVER DETROIT RIVER.

To the Board of Commissioners to inquire into the practicability of bridging Detroit River:

For the purpose of harmonizing, as far as possible, the apparently conflicting interests between the vessel-owners and the railroad companies, we herewith submit the

proposition on behalf of the Michigan Central and Canada Southern Railroads, that a grant from the Government, allowing said roads to construct winter-bridges over the Detroit River, with two openings of 400 feet each, and a draw of 166 feet to each bridge, will be cheerfully accepted and acted upon by said railroads.

A. B. MAYNARD,
Of Counsel for Michigan Central Railroad.
E. W. MIDDLEBURY,
Of Counsel for Canada Southern Railroad.

Dated DETROIT, November 18, 1873.

XI.—DETROIT RIVER TUNNEL—A PAPER BY ENGINEER CHESBROUGH.

The following paper on the Detroit River tunnel was read by Mr. E. S. Chesbrough, its engineer, before the Society of Civil Engineers at Louisville :

At the date of the former paper on this subject, read at the last convention, the preliminary work on the Detroit River tunnel was in a very encouraging state. The Detroit shore-shaft had been sunk, and a drainage-tunnel extended from it for about 600 feet toward the Canada end. The Windsor shore-shaft had been sunk to below the bottom of the drainage-tunnel, which had progressed 100 feet toward the Detroit end. With the exception of finding harder ground, and consequently making slower progress than had been originally expected, the prospect of a successful completion of the work was brighter than at its inception, since previous to sinking the Detroit shaft there was a fear that very troublesome veins of water, supplied from the land, and having a higher source than the river, might be met. For this reason the Detroit shaft was sunk first, as the borings on the Windsor side did not indicate such veins of water.

In the latter part of July, 1872, when the work on the Windsor end had progressed about 250 feet through, for the most part, very hard ground, some of which was blasted, a sudden irruption of sand and water occurred which threatened to fill the tunnel out to the sump and choke the pumps. To prevent this a bulk-head was constructed near the face, but before it could be made sufficiently tight the workmen had to retreat some distance to make an apparently successful stand; and even this did not prove sufficient, so that a third and last bulk-head, still nearer the shaft, was put in. This state of things looked very discouraging, and it was, of course, impossible to tell the exact nature and extent of the source of the irruption, or how long it would continue.

From the character of the water itself, as well as from other circumstances, it evidently did not come from the river, and there was reason to hope its flow would soon diminish. This hope was not disappointed, and about the 14th of August the face was again reached, the bulk-heads having been removed. Regular operations were resumed, but, after 30 feet of new tunnel had been built, a fresh irruption of sand and water occurred, making it again necessary to put in bulk-heads, preventing further advance for four days more. By this time it was concluded that the source of the irruption must be a vein, and not merely a pocket of sand; still it was hoped that it might prove quite limited in extent, and soon be passed. On the 12th of September, after the work had been extended 47 feet further, a third irruption occurred. After another placing and removing of bulk-heads, and taking out of sand, causing a delay of five days, regular operations were resumed, and 10 feet advance made, when a further irruption occurred.

By this time the contractors had become very much discouraged, and felt that to continue the drift on the same level would be ruinous to them, as the work was costing more than four times the price they received for it. Inasmuch as the work on the Detroit side had been extended about 1,200 feet, sufficiently far to drain the lowest portion of the main tunnel, and inasmuch as the principal object now remaining was to explore the ground through which the main tunnel was to be built, it was decided to make a "lift-shaft" at the end of the drift, on the Windsor side, and get into the ground through which it was proposed to construct the main work, thus avoiding, if possible, the irruption which had been so troublesome. This was accordingly done, and a new drift started at a level 10 feet higher than that of the drainage-tunnel. The ground was much easier to excavate, but the irruptions, which formerly came from the top of the excavation, now came up through the bottom, there being a vein of sand at the level of the top of the lower drift. This was not quicksand, nor usually running, and was only brought in, when it did come, by the force of running water. On reaching a point about 370 feet from the shore-shaft an irruption occurred that continued so long that it seemed as if further progress in that direction was impracticable in so small a drift, with the ordinary means of tunneling.

Before describing the further steps taken at this end of the tunnel it will be well to mention what had been encountered on the Detroit side. The work there was

carried on without any serious difficulty, and at a satisfactory rate of progress, until a point 1,100 feet from the shaft was reached. There the quantity of water coming from the bed-rock immediately beneath increased considerably. Gas had been more or less troublesome most of the way, sometimes making the men's eyes so sore that they had to quit work for a while. When a distance of about 1,180 feet had been reached the machinery for ventilating the tunnel proved inadequate, and some delay was occasioned by having to put in more.

Before the ventilating-apparatus was started again, a man went out to the end of the work and returned, without having been injuriously affected by the air, which he said was bad. He reported a sand-leak at the face. Two others then went out to stop the leak, which they expected to do in a few minutes; but they never returned alive. When they had remained as long as was thought necessary, the foreman sent a man to order them back if their eyes were affected by the gas. He returned and said they were dead. Others went in for them, but were unable to get them out alive, although one of them showed signs of life when first reached. It was only after several attempts, at great risk, that their bodies were recovered. Previous to this no one connected with the work had feared any fatal result from inhaling the gas, the greatest evil apprehended being sore eyes.

After the new ventilating-apparatus was set in motion, regular operations were resumed, and the work was extended to a point 1,220 feet from the shaft. The influx of water here became so great as to require more powerful pumping-machinery. It was thought best, however, not to require the contractors to incur this expense at the time, but to let them suspend work at this end until further developments were made at the Windsor side, where the prospect, as previously stated, was so discouraging.

At this juncture the contractors requested to be relieved from all further obligation to prosecute the work under their contract, which the directors agreed to, on conditions not necessary to mention here.

It was then determined to carry on the work at the Windsor end by the day, by means of two parallel trial-drifts, and to begin the second one at the shore-shaft, at a level ten feet above the grade of the drainage-tunnel, leaving the latter to be used as a sand-holder in case of further eruptions. Thus it was hoped that in either one or the other of the parallel drifts some progress might constantly be made, experience having shown that a stream of sand and water flowing into the tunnel at one point would never be accompanied by a troublesome one flowing in at another. In fact it was observed that water which flowed from an orifice which at first discharged sand as well as water ceased flowing either shortly before or just when a new eruption occurred at the face.

The upper drift, for a distance of about 380 feet from the shore-shaft, was easily constructed, in some cases upward of 20 feet of progress being made in twenty-four hours. This drift was continued to the right of the old one, beyond the lift-shaft, and no irruption occurred in it until an advance of about 20 feet was made beyond the face of the old or first drift. There an irruption occurred, and the water and sand ceased flowing into the old drift, which was extended 50 feet before the water returned to it, and left the new one free. The latter was in turn extended about the same distance, when the water changed over to it. Thus the work was carried on alternately in the old and new drifts, when the directors, becoming discouraged at its slow progress and excessive cost, ordered it stopped. The actual advance in the new ground during the last two months was only 60 feet, and the cost about \$7,500, or more than six and one-half times the contract price.

Besides the discouragements connected with the work, the usual severity of last winter caused such an interruption in the movement of freight across the river at Detroit as to amount almost to strangulation, certain and speedy relief from which was felt to be an absolute necessity, otherwise the already very heavy and constantly increasing business of the two railways interested must be largely diverted into other channels.

The decided refusal of the Canadian Parliament, a few years since, to grant a bridge charter has been succeeded recently by the granting of one to a company whose road crosses only a few miles below Detroit, on condition that Congress shall grant one also. The matter is now the subject of investigation by United States engineers, who are to report before the next meeting of Congress.

While the construction of the Detroit tunnel, as a simple engineering problem, cannot seem otherwise than practicable to the members of the profession, especially in the light of the experience gained in the Thames tunnel, and other works completed since, the advisability of constructing it, as a judicious expenditure of money, was left to be fully settled by the making of a drainage-tunnel. The engineer believed, from the original borings, and from the earlier operations of the drainage-tunnel, that the main work was not only practicable, but desirable; later developments, however, throw much doubt upon its advisability.

It remains to answer several questions which will very naturally occur to members of the society, such as—

1st. Why was not the character of the veins of sand which gave so much trouble revealed by the borings made before the work was begun? The borings did frequently pass through small deposits of sand, but pockets of this material are so common in drift-clay that nothing is thought of them in ordinary tunneling. As already mentioned, fears were entertained that trouble from a great influx of water might be encountered in the Detroit end, but no such difficulty occurred there.

2d. Why could not the orifices through which the irruptions occurred be stopped? This experiment was tried several times, but it always ended in making matters worse instead of better. If the influx was stopped at one point it broke out at another. If the whole face was carefully protected against it, the fresh points in the masonry would be washed out. This will not be wondered at when it is stated that the source of the impressing water was ascertained, after the stoppage of work, to be more than 100 feet above the bottom of the drainage-tunnel.

3d. Why could not a shield have been used to advantage? This was thought of, but experience both in Chicago and elsewhere had shown that shields in such small drifts, through soft clay, are exceedingly difficult to keep in line. Such would have been especially the case in this work, where after each irruption the end of the masonry, and toward the last the timbering, were so twisted and broken laterally and vertically as to require rebuilding in several instances.

4th. Could not the work have been carried on by the pneumatic process? Besides the fact that no horizontal drift of any length is known to have been made in this manner, it will be sufficient to state to those familiar with the process that work executed under a pressure equal to 90 or 100 feet head of water is not only very expensive, but hazardous to human life.

Another reason for not excluding the sand permanently, if it could be done, was that by letting it come in till it ceased to flow of itself, the ground would be left in a much better state for the main work. This belief was confirmed by making the second and parallel drift, in which no irruption occurred until after all the old ground worked in had been passed through.

XII.—ANSWERS BY MR. F. N. FINNEY, CHIEF ENGINEER CANADA SOUTHERN RAILWAY, TO QUESTIONS PROPOSED TO RAILROAD AND BRIDGE COMPANIES BY THE BOARD OF ENGINEERS.

1st. The Canada Southern Bridge Company propose to cross the Detroit River at a point about one and a half miles above Amherstburg. The Canada Southern Railway and the Michigan Midland and Canada Railway Companies propose to cross the St. Clair River just below the city of St. Clair, in Michigan.

2d. The railways connected by the Detroit River crossing are, the Canada Southern main line on the east, the Chicago and Canada Southern on the west, which at Chicago connects with all the principal lines leading west, and the Toledo, Canada Southern and Detroit Railway, the latter being a connecting-link between the Toledo, Wabash and Western Railroad; the Cincinnati, Hamilton and Dayton Railroad, the Dayton and Michigan Railroad, and other railways of the South and West; and also the railways from the North and West terminating at Detroit. The railways connected by the crossing of the St. Clair River are, the Canada Southern, (St. Clair branch,) the Michigan, Midland and Canada Railway, and other railways leading into the lumber and mineral regions of Upper Michigan, and which seek an outlet over the Canada Southern Railway to the east; the distance from St. Clair to Buffalo over this route being only one hundred and eighty-five miles.

3d. Attached schedule A is the profile of Detroit River. No extensive borings have been made, but the bed of the river is limestone, displaced and permeated with fissures. The piers would be of stone, on rock foundations, 7 feet in thickness and 23 feet in length, under the copings and the spans, which would be of iron, about 200 feet in length.

The attached schedule, marked B, is the profile of St. Clair River. The bed of the river is clay, and the piers would be of the same general style and size as those in the Detroit River, but the foundations would be on piles. The spans and structures would be similar to those at the Detroit River crossing. The bridge over Detroit River could be built in two years, and the one over St. Clair River would probably require three years to build, owing to the increased labor in preparing foundations.

In answer to the fourth section of the third interrogatory, we consider the plan of a bridge with a clean headway of 150 feet impracticable, in consequence of the low banks and other channels adjacent thereto.

In answer to the fifth section of the third interrogatory, we do not consider a bridge built solely for winter use, to be removed during summer or the season of navigation, practicable in operating a bridge for railway purposes at the points hereinbefore mentioned.

The draw of the bridge would stand open during the season of navigation, excepting while trains were actually passing, which would occupy not to exceed from one minute to one and a half minutes for each train.

4th. We do not consider the project of a tunnel at either of the crossings feasible. At the first for the reason that the rock is so permeated with seams that it would be practically out of the question to construct a tunnel. At the second crossing for the reason that the bed of the river, so far as examined, presents a similar formation to that found in the experimental tunnel commenced under the Detroit River at Detroit by the Michigan Central and Great Western Railway Companies, and which proved that a tunnel would be quite impracticable.

In answer to the fourth section of the sixth interrogatory, reference is respectfully made to the report submitted by the Michigan Central and Great Western Railway Companies.

The Canada Southern not being in operation at this date, no data are at hand touching these questions.

F. N. FINNEY,

Chief Engineer Canada Southern Railway.

XIII.—STATEMENT OF CAPT. W. R. CLINTON IN FAVOR OF FERRYING CARS ACROSS DETROIT RIVER.

I have been a ferryman on the Detroit River thirty years, and in charge of a ferry-steamers twenty-two years. My father was a ferryman on the Detroit River twenty-four years; in fact, my time has been entirely devoted to ferrying and building ferry-boats since I arrived at an age to be useful to myself or father.

I have stock in the company to which the Victoria belongs. This new boat was built and put on the ferry in December, 1872. I modeled her and superintended her building and her machinery, and have sailed her as master since. She is the kind and style of boat that I have been desirous of building for the last twelve years, but had not capital enough within myself to do it. In 1871 I was able to get capitalists to take hold with me and build the Victoria. It was the distinct agreement, in agreeing to build this steamer, that I should use my own plans and specifications in every particular, and in due course of time I brought the Victoria to the dock ready for business. She is 192 tons burden, 108 feet long, and 28 feet beam. She has been constantly employed from December, 1872, and the longest time occupied in crossing the river during the winter 1872-'73 was nine minutes.

Last winter we had the heaviest ice of any winter during the last nineteen years, and in no case were we longer than nine minutes in crossing from Detroit to Windsor, while the railway ferries were one hour and upwards.

I say I can build a boat, or any number of boats, that will run in the heaviest ice we had last winter, from the Michigan Central Railroad dock to the Great Western Railroad dock, in twenty-five minutes, and carry at least fourteen loaded cars. This is double the distance it would be to run directly across the river.

I am so sure that I can build such boats and make them successful, that I would be willing and glad of the chance to put all my time, talent, and means into such boats as a life business.

Everything I promised my stockholders to do with the Victoria, I have done, and more; and, with my experience in building and operating her, I know that by not being limited to size of boat or quantity of money, I can far exceed the doings of the Victoria in her business abilities.

W. R. CLINTON.

Capt. W. R. Clinton is an old river-captain, and is, in my judgment, the most competent person in this city to judge of the capacity of steamers to cross the Detroit River during winter or summer.

E. B. WARD.

XIV.—STATEMENT OF CAPT. JOSEPH NICHOLSON AGAINST BRIDGING DETROIT RIVER

To the Board of Engineers appointed by the War Department to investigate the subject of bridging the Detroit River.

GENTLEMEN: I have been requested to address you on the question of bridging the Detroit River, and what effect it would have on the vessel-interests, so far as such bridging would increase the dangers of navigation. In presenting my views, gathered from personal experience as a seaman, and from observation since I quit sailing, I will

endeavor to be as brief as possible, and not undertake to tell of things foreign to this subject.

I presume you do not care to know whether the roads that terminate in this city pay any dividends or not, or why it costs more to carry a barrel of flour or pork from any point over one hundred miles from here, not reached by lake or canal, than it does from Chicago, unless it can be shown that the want of a bridge has something to do with such things, but the producers who live at way-stations that have no outlet by water have an interest in some of the above questions, and as this question is said to be of almost national importance, it might be well to give this case a few thoughts to see how their freight would be made lower by an extra expenditure of several millions that must be made up from local business, for I believe it is not claimed that through-rates have brought any profit, particularly from points reached by the lake and rivers.

I commenced sailing on the lakes in 1844, and continued on them until 1866. For four years of that time I sailed as master and part owner of a first-class tug, and seven years as master of steamers and propellers, and since 1866 I have been employed by the Detroit Fire and Marine Insurance Company as its marine inspector.

I will not pretend to say that a tow of five vessels could not be taken through the draw of a bridge 160 feet wide in fine weather, where the bridge was directly across the current, but I do state that there are many times during the season that it could not be attempted with any degree of safety, especially if the wind was from any other quarter than nearly right ahead, for the drift of the vessels toward the end of the tow would be increased in accordance with the speed of the wind at the time; and it would not be safe or prudent to attempt to overcome this drift by an increase of speed in passing through the draw, for it is a fact beyond dispute that vessels can be taken through all such narrow places much safer when taken with just sufficient steerage-way on than at any greater speed. Consequently the drift or lee-way made by the stern vessels of a tow would be greater in a strong beam-wind than the width of the proposed draw. Vessels do not answer the helm so quick in a tow as by themselves, and to attempt to overcome the drift by an increase of speed would be very hazardous; for if the head or other vessel should take the least sheer, it would be pretty sure to put all behind her in bad shape, and very much lessen their chance of going through without striking either side of the abutments. Besides the beam-winds there are other causes that would make a bridge a very serious danger to navigation, and at some points more so than others. You, of course, are aware that a dense fog is about all that stops the tugs, either night or day, and that a steamer must in all cases give way to a sailing-vessel. Now, supposing a tug, with five, six, or seven vessels, in approaching the bridge from above at night, with only a moderate breeze blowing from, say, the south, and, when within a short distance of the draw, should meet a sailing-vessel bound either way, that would compel her to alter her course a point or more, and it would be impossible to get that tow in line again before getting to the bridge; and to approach it in any other way than in a straight line would be sure damage to an extent told only when too late to prevent it.

You also are aware that vessels, in passing through the bridge, have to contend with the acts of each other, each one looking to his own safety only, without any regard to how their position would affect others, nor is there any law to compel them to do so, so long as they conform to the well-known rules of sailing.

Now, as there are quite a number of small craft navigating these rivers that never tow, a tug or steamer is just as liable to meet one or more just when getting in position to go through, as at any other time or place, all of which make such an obstruction more dangerous; and as for vessels beating through, that I should say would be a thing seldom attempted.

I might go on and call your attention to other dangers that would arise in consequence of a bridge being put across the river at this point, but I do not wish to occupy too much of your time; besides, you are well posted in many I would mention, such as change of direction and speed of the current caused by, and close to, the piers or abutments of a bridge, and how it would affect vessels in passing between the same.

An attempt has been made to compare dropping a raft through the draw of a bridge across the Au Sable River, a stream but little wider than a raft, where the wind cannot strike it, and towing one through a similar structure across the Detroit River, for the purpose of showing the latter would not be a serious obstruction to navigation, so far as raft-towing was concerned, and I can only say that in making the above comparison the person doing so showed he was entirely ignorant of the subject, for it is a fact well known to every intelligent man who has had a personal experience in towing rafts that it requires but a moderate breeze of beam-wind to drift the after end of a long raft a far greater distance from a straight line than the width of the draw of any bridge, and in consequence could not be got through without fouling the abutment and breaking up the raft; besides the beam-wind, there are other causes, well known to every competent tug-master, that would make a bridge an obstruction very much feared even to raftsmen.

Much has been said about the bridges across the Ohio and Mississippi Rivers being no obstacle to their being safely navigated. Gentlemen, there is no comparison, as our

mode of towing and sailing and the kind of vessels are so widely different, that I will not occupy your time with any further remarks, as I believe you are perfectly familiar with both.

I will not take up any time on the question of the great loss said to be sustained by the railroads, caused by the ice blocking the river during a part the winter, for, I believe, you will have facts enough brought before you to show that such a loss is only in the imagination, and not in fact.

For many years the people of the Northwest, and of Michigan in particular, have been asking Congress for large appropriations of money to improve our harbors and remove obstructions from our rivers, and they never could get enough, and now we have a few asking Congress to place obstructions across our rivers to spoil the natural outlet for the products of the great Northwest, and, as a consequence, increase the cost of transportation; for, when you stop navigation, up goes the freight by rail.

In conclusion, gentlemen, permit me to ask you to consider well this subject before you recommend that permission be granted for a bridge, for I believe such would be a very serious and costly obstruction to the safe navigation of our rivers.

Very respectfully, yours,

JOSEPH NICHOLSON.

DETROIT, November 20, 1873.

Capt. J. Nicholson has been an able and respected sailing-captain and insurance-agent. I am well acquainted with him, and have full confidence in his judgment and views on any subject pertaining to the navigation of the lakes.

E. B. WARD.

Q 3.

ST. LOUIS AND ILLINOIS BRIDGE ACROSS THE MISSISSIPPI RIVER.

Letters of the Chief of Engineers.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., March 26, 1874.

SIR: I had the honor October 6, 1873, of submitting to you the report, dated September 11, 1873, of a Board of Engineers convened at St. Louis, Mo., by Special Orders, No. 169, War Department, Adjutant-General's Office, dated August 20, 1873, "to examine the construction of the St. Louis and Illinois bridge across the Mississippi River at St. Louis, and report whether the bridge will prove a serious obstruction to the navigation of said river, and if so, in what manner its construction can be modified." A copy of the report was furnished to the bridge company.

The Board was reconvened on January 14, and on January 31 a supplementary report was submitted by it.

I now have the honor to transmit copies of the two reports of the Board, and, concurring in their views respecting the obstruction to navigation which the peculiar construction of the bridge forms, to renew my recommendation that the subject be submitted to Congress.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers

Hon. W. W. BELKNAP,
Secretary of War.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 6, 1873.

SIR: Congress, by acts approved July 25, 1866, and July 20, 1868, (Statutes at Large, vol. 14, pp. 245, 246; vol. 15, p. 123,) authorized the St. Louis and Illinois Bridge Company to build a bridge across the Mississippi River at St. Louis, Mo. This bridge is now in process of construction, and, representations having been made, by parties interested in preserving the free navigation of the river, that the bridge, when completed, would materially obstruct and injuriously modify that navigation, a Board of officers of engineers was ordered to convene at St. Louis, and, after a careful examination of the whole subject, to "report whether the bridge will prove a serious obstruction to the navigation of said river, and if so, in what manner its construction can be modified."

The Board met in accordance with the order, and in pursuance of their instructions made a report, which is herewith respectfully submitted.

The Board confined itself strictly to the consideration of the question whether the bridge will prove to be a serious obstruction to the navigation of the Mississippi River, and if so, to the remedy therefor. Having obtained from the representatives of the navigation interests on the one hand, and from the officers of the bridge company on the other, the statistics and drawings necessary to a clear comprehension of the subject, and having caused examinations and measurements to be made under their own direction to assure the accuracy of the latter, the Board are unanimously of the opinion "that the bridge, as at present designed, will prove a very serious obstruction to the free navigation of the Mississippi River." The Board, in addition, state that arched trusses like those in the bridge under consideration "present so many difficulties to free navigation, that in future their use should be prohibited in plans for bridges over navigable streams." No satisfactory plan for changing the present structure could be decided upon; and as it was deemed "absolutely necessary that some provision should be made for allowing large boats to pass the bridge with safety," when necessary, the Board recommend "as the most feasible modification a plan which has been already tried and found efficient at the railroad bridge over the Ohio River at Louisville, Ky.," viz: "A canal, or rather an open cut, be formed behind the east abutment of the bridge, giving at the abutment a clear width of water-way of 120 feet." The shore side of this cut to be laid out on an easy curve joining the general shore-line about 500 feet above the bridge, and about 300 feet below it. This opening to be spanned by a draw-bridge, giving a clear span of 120 feet in width. This plan would enable boats of the largest class to pass the bridge in any weather, and at any stage of water, with but little delay. The steamboat interest would, it is stated, be satisfied with this modification, and the bridge company object to it only on account of the delay to railroad trains caused by the opening and closing of the draw.

Detailed estimates of the cost of this modification can only be given after a special survey and study of the locality.

The modification proposed by the Board will not interrupt the work of constructing the bridge.

The views and recommendations of the Board are concurred in by me, and it is recommended that the matter be submitted to Congress at its next session for such action as in their judgment may seem to be necessary.

It is further suggested that the Chief of Engineers be authorized to

furnish the bridge company with a copy of this communication and the report of the Board

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers.

Hon. W. W. BELKNAP,
Secretary of War.

The recommendations of the Chief of Engineers are approved by the Secretary of War, October 10, 1873.

H. T. CROSBY,
Chief Clerk.

Report of the Board of Engineers.

ENGINEER OFFICE, UNITED STATES ARMY,
St. Louis, Mo., September 12, 1873.

GENERAL: I have the honor to transmit herewith, for your consideration, the report of the Board of engineer officers convened by Special Orders No. 169, War Department, Adjutant-General's Office, Washington, August 20, 1873, to examine and report on the Illinois and St. Louis bridge.

The papers furnished for the information of the Board are herewith returned.

I am, general, very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

ENGINEER OFFICE, UNITED STATES ARMY,
St. Louis, Mo., September 11, 1873.

GENERAL: The Board of engineer officers convened by Special Orders No. 169, War Department, Adjutant-General's Office, Washington, August 20, 1873, "to examine the construction of the St. Louis and Illinois bridge across the Mississippi River at St. Louis, and report whether the bridge will prove a serious obstruction to the navigation of said river; and if so, in what manner its construction can be modified," have the honor to submit the following report:

In considering the subject laid before them, the Board have confined themselves strictly to their instructions, which direct them to ascertain whether the bridge, as being built, will be a serious obstruction to the navigation of the Mississippi River; and if so, what modifications can be made in its construction.

They have not undertaken to decide whether the bridge is, or is not, being built in conformity to the acts of Congress authorizing its construction, although this question will be of importance when it becomes necessary to decide who shall pay for such modifications as may be determined on.

The Board have obtained from the steamboat-men who complain of the present structure a statement of their objections and the reasons therefor.

They have obtained from the officers of the bridge company such drawings and statistics as were needed for a clear comprehension of the nature of the structure, and have caused a sufficient number of meas-

urements to be taken to assure them that the drawings herewith submitted are substantially correct.

Appended to this report are the following documents and drawings :

A. Copy of special order convening the Board.

B and C. Copies of acts of Congress authorizing the construction of the bridge.

D. Tracing giving profile of bridge and approaches, (furnished by the bridge company.)

E. Tracing showing elevation of center and west spans of bridge, and portion of western approach, (furnished by the bridge company.)

F. Tracing showing the outline of the lower part of the superstructure as originally designed, and as now being constructed, (furnished by the bridge company.)

G. Water-record of the port of St. Louis for the last thirteen years giving the duration of various stages for each month of each year, and also some special observations, taken previous to the continuous records. (Compiled by the board from the official records.)

H. Tabular recapitulation of the above, giving the duration of various stages for each year, the average yearly duration of each stage, with the corresponding heights under the center of the middle span, and the heights available for a width of 174 feet, or 87 feet on each side of the center of the arch.

I. Drawing showing outline of center arch, with lines of extreme high and low water, and also the width of clear headway available at different heights above extreme low-water. (Prepared by the Board.)

K. Tabular statement giving the most important dimensions of some of the principal steamboats plying to and from the port of St. Louis. (Furnished by the Boatmen's Association of St. Louis.)

L. Diagram giving graphically the heights of chimneys and pilot-houses of steamboats enumerated in the preceding list, and showing the relative height of the chord of center arch, which is 174 feet long and 5 feet below the crown of the arch, for different stages from extreme low-water of 1863 to extreme high-water of 1844. (Prepared by the Board.)

These drawings, &c., present the general features of the structure so clearly that a detailed description seems unnecessary.

The objections made to the bridge are as follows, viz :

1st. The height under the lower arch is so small that a large proportion of the boats which will have occasion to pass under it must lower their smoke-stacks at all, or nearly all, stages of the river, while many of the larger boats will not be able to pass under it during the higher stages, even with their smoke-stacks down.

2d. The small height afforded is only available for a portion of the whole span, owing to the arch-form of the lower part of the superstructure. Moreover, the difficulty of passing under the exact center of the arch will be very great, especially in foggy or windy weather, and any considerable deviation to either side may bring the boat's upper works in contact with the bridge.

3d. These difficulties would probably deter most boats from ever passing the bridge, thereby preventing the ready transfer of freight from one boat to another, or its delivery and shipment at different parts of the city, without resorting to costly transfers by drays or barges. This, it is claimed, would practically cut the Mississippi River in two at this place.

An examination of Appendixes K and L will show that the first point is well sustained. The list of boats enumerated therein comprises only those which happened to be in port at the time the Board was in session, or whose dimensions were attainable. It might have been increased considerably had time been available.

The apparently unreasonable height and size of the chimneys in general use on these steamboats, are really essential to secure a good draught to the furnaces and economical combustion of fuel. Artificial means to produce the same end are generally very expensive, and often ineffective.

Although it is a comparatively easy task to lower *small* chimneys, dealing with those of large size is a very serious matter indeed. Their weight is so utterly disproportionate to their strength, even when new,

that no machinery yet devised will enable large chimneys to be lowered either wholly or in part, without very great labor and danger.

The elevated position of the pilot-house is necessary to enable the pilot to have an unobstructed view of the river ahead and astern of his boat. Experience has decided this point most clearly.

The second objection is mainly owing to the peculiar system of superstructure employed, and which we understand was adopted principally on the ground of economy. Appendix I gives the widths which are available under the center span at different heights above extreme low-water. The side spans have not been considered, as they are four feet lower than the central one.

Appendix F shows the lower line of the superstructure as originally designed, with the railroad-tracks below the arch for a portion of the width (226 feet.) By a subsequent modification, the lower arched tube was lowered 4 feet at the crown, while the railroad-tracks were raised through a similar distance. This brings the roadway entirely above the arch and increases the height at the center of the arch about 4 feet. The practical conditions are, however, but little altered by this modification. The full height is only given at the exact center of the arch, and in order to consider the matter in its practical bearing, it is necessary to assume that some definite width will be required for the safe passage of a boat.

The width of draw-spans required by congressional legislation up to this date varies from 160 to 200 feet. The former width would be too small for the large boats used on the Lower Mississippi, and an approximation to the greater width would probably be necessary. The horizontal chord of the center span, which lies 5 feet below the crown of the arch, is 174 feet long, and gives the least width of water-way which seems compatible with safe navigation. The height of this chord is 50 feet above the city directrix. It may therefore be assumed that a boat no portion of whose structure extended above this limiting height, might pass safely under the bridge, provided that the pilot was enabled to keep her within the space mentioned, viz, 87 feet on each side of the center of the span. The position of this chord with reference to different stages of water is given in Appendix L, which also shows the relative height of the chimneys and pilot-houses of a large number of the boats which will wish to pass under the bridge when it is completed.

There remains still to be considered the practical difficulty of keeping a boat within the limited width necessary for safety.

It is the opinion of the Board that this will be a matter of very great uncertainty, and this is also the view taken by intelligent pilots who were questioned on this point. They maintain that the same width of water-way between piers with clear headway above, would be far preferable. The reason given for this is that the piers would define the available width with exactness; they are easily seen and can be avoided. In case of wind a boat can be dropped through the opening by lines made fast to ring-bolts on the pier itself.* In case of striking them under headway the damage done is to the hull alone, and, even if so great as eventually to sink the boat, time will generally be afforded to save the lives of the crew and passengers.

In the case of a wide arch, however, the case is different. The piers are too far apart to be of service as guides, and lights placed on the structure will be so nearly overhead as to be of no great assistance. If range-lights could be placed at some distance above and below the bridge

* In this case the piers would have to be extended up stream about 400 feet by cribs, piles, or other suitable means.

the difficulty might be mitigated, but in a crowded harbor like that of St. Louis it would be almost, if not quite, impossible to give the lights sufficient individuality to avoid the chance of mistakes. Moreover, in foggy weather the lights could not be seen. In case of wind there would be great danger of a boat sheering or making so much leeway as to come in contact with the bridge. In this case the shock would come upon the light upper works, which would probably be destroyed. As the passengers are carried on the upper decks, such an accident would probably be attended with great loss of life.

The chance of dropping through along the pier is not available in this case, as the arch of the center span springs from a point about at the level of high-water of 1844.

The third objection seems fairly sustained by the facts already cited, especially when it is remembered that the principal part of the river business is done during the higher stages of water. The large New Orleans boats, for instance, rarely attempt to do business after the river gets to a lower stage than 20 feet above extreme low-water.

A large portion of the St. Louis river front is above the bridge, and several elevators, a sugar-refinery, and other similar buildings, are already located above it. These could not safely be reached during high stages by the large boats navigating the lower river; and much inconvenience and expense would thus be entailed; but the Board consider these interests in a measure local, and of infinitely less importance than the national interests involved in the question. The Government has expended, and is still expending, large sums of money in improving the navigation of the Upper Mississippi, Missouri, Illinois, and other rivers, for the express purpose of allowing the largest steamers to navigate them. It would, therefore, seem entirely out of keeping with this general policy to allow, at the very threshold of these improvements, a structure which would practically debar a large proportion of existing steamboats from using them.

The Board are, therefore, unanimously of the opinion that the bridge, as at present designed, will prove a very serious obstruction to the free navigation of the Mississippi River.

They would, moreover, state that arched trusses like those under consideration present so many difficulties to free navigation, that in future their use should be prohibited in plans for bridges over navigable streams.

The Board have very carefully considered the various plans proposed for changing the present structure, but find none of them satisfactory.

The piers being only made strong enough to withstand the thrust of the unloaded arches, it will be impossible to raise separately either of the spans, or to substitute for one of them a straight truss or a suspended roadway. The practical difficulty of raising the entire structure would be very great, as well as enormously costly.

Moreover, in any such plan, the present approaches, including the costly tunnel under a portion of the city of St. Louis, could not be used without considerable modification, as the steamboat-men deem a clear height of 75 feet above high-water the least admissible.

Under these circumstances the Board do not feel justified in recommending any change which would involve a complete remodeling of this magnificent structure, now so nearly completed. At the same time, as already stated, they deem it absolutely necessary that some provision should be made for allowing large boats to pass the bridge with safety whenever they find it necessary to do so.

They would, therefore, recommend, as the most feasible modification,

a plan which has been already tried and found efficient at the railroad bridge over the Ohio River at Louisville, Ky.

Let a canal, or rather an open cut, be formed behind the east abutment of the bridge, giving at the abutment a clear width of waterway of 120 feet. The shore-side of this cut should be laid out on an easy curve, joining the general shore-line about 500 feet above the bridge and about 300 feet below it. The river-side may be entirely open, but the shore-side should be revetted vertically with stone or with crib-work to a height of about 5 feet above extreme high-water. This wall should be provided with ring-bolts and posts, to enable boats to work through the cut with lines.

Let this opening be spanned by a draw-bridge giving a clear span of 120 feet in width.

By this plan boats as large as any now built would be able to get through the bridge in any weather and at any stage of water, and only at the cost of some little delay.

The steamboat-men have stated to the Board that they would be satisfied with this modification, and the engineers of the bridge company only raise as an objection the delay to trains caused by opening and shutting the draw. While recognizing the validity of this objection, the Board deem that the difficulty can be mitigated, if not entirely overcome, by providing machinery capable of opening and closing the draw with any desired rapidity. The use of this draw by the boats will be only in cases of necessity, and the inconvenience which this use may occasion to travel on the bridge there seems no course left but to submit to.

Detailed estimates of the cost of this proposed modification can only be made after a special survey and study of the locality. Owing to the pressure of their other official duties the Board deem that it would be impossible for them to remain in session while these surveys and calculations are being made, and would, therefore, recommend that it be made a special duty of the local engineer officer to prepare and submit the estimate.

Whether this modification be carried out or not, the Board deem it very important that such lights and marks be displayed by the bridge as will enable boats not only to distinguish the position of the piers and arches with certainty, but also to be able to tell the clear headway available under the bridge.

The modification proposed by the Board will not require the present work of constructing the bridge to be interrupted, and the only action which seems necessary is to submit this matter to Congress at its next session, with the recommendation that action be taken to enforce the modification, and at the same time to determine by whom it shall be carried out.

Respectfully submitted,

J. H. SIMPSON,

Colonel of Engineers and Brevet Brig. Gen., U. S. A.

G. K. WARREN,

Major of Engineers and Brevet Major-Gen., U. S. A.

G. WEITZEL,

Major of Engineers and Brevet Major-Gen.

WILLIAM E. MERRILL,

Major of Engineers and Brevet Colonel.

CHARLES R. SUTER,

Major of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

A.

[Special Orders No. 169—Extract.]

WAR DEPARTMENT,
 ADJUTANT-GENERAL'S OFFICE,
 Washington, August 20, 1873.

10. A Board of Engineers, to consist of Col. James H. Simpson, Maj. Gouverneur K. Warren, Maj. Godfrey Weitzel, Maj. William E. Merrill, Maj. Charles R. Suter, is appointed to meet at St. Louis, Mo., on the 2d day of September, 1873, or as soon thereafter as practicable, to examine the construction of the St. Louis and Illinois bridge across the Mississippi River at St. Louis, and report whether the bridge will prove a serious obstruction to the navigation of said river; and, if so, in what manner its construction can be modified.

The junior member of the Board will act as recorder.

By order of the Secretary of War :

E. D. TOWNSEND,
Adjutant-General.

Official :

J. P. MARTIN,
Assistant Adjutant-General.

A true copy :

J. H. SIMPSON,
Colonel of Engineers.

B.

[Extract.]

AN ACT to authorize the construction of certain bridges and to establish them as post-roads.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be lawful for any person or persons, company or corporation, having authority from the States of Illinois and Missouri for such purpose, to build a bridge across the Mississippi River at Quincy, Ill., and to lay on and over said bridge railway-tracks, for the more perfect connection of any railroads that are or shall be constructed to the said river, at or opposite said point, and that when constructed all trains of all roads terminating at said river, at or opposite said point, shall be allowed to cross said bridge for reasonable compensation, to be made to the owners of said bridge, under the limitations and conditions hereinafter provided. And in case of any litigation arising from any obstruction, or alleged obstruction, to the free navigation of said river, the cause may be tried before the district court of the United States of any State in which any portion of said obstruction or bridge touches.

Sec. 2. *And be it further enacted,* That any bridge built under the provisions of this act may, at the option of the company building the same, be built as a draw-bridge, with a pivot or other form of draw, or with unbroken or continuous spans: *Provided,* That if the said bridge shall be made with unbroken and continuous spans, it shall not be of less elevation in any case than 50 feet above extreme high-water mark, as understood at the point of location, to the bottom chord of the bridge; nor shall the spans of said bridge be less than 250 feet in length; and the piers of said bridge shall be parallel with the current of the river, and the main span shall be over the main channel of the river, and not less than 300 feet in length.

SEC. 11. *And be it further enacted,* That the St. Louis and Illinois Bridge Company, "a corporation organized under an act of the general assembly of the State of Missouri," approved February fifth, eighteen hundred and sixty-four, and an act amendatory of the same, approved February twentieth, eighteen hundred and sixty-five, and also confirmed in its corporate powers under an act of the legislature of the State of Illinois, approved eighteen hundred and sixty-four, or any other bridge company organized under the laws of Missouri and Illinois, be, and the same is hereby, empowered to erect, maintain, and operate a bridge across the Mississippi River, between the city of St. Louis, in the State of Missouri, and the city of East St. Louis, in the State of Illinois, subject to all the conditions contained in said act of incorporation and amendments thereto, and not inconsistent with the following terms and provisions contained in this act. And in case of any litigation arising from any obstruction, or alleged obstruction, to the free navigation of said waters, the cause may be tried before the dis-

trict court of the United States of any State in which any portion of said obstruction or bridge touches.

SEC. 12. *And be it further enacted*, That the bridge authorized by the preceding section to be built shall not be a suspension-bridge or draw-bridge, with pivot or other form of draw, but shall be constructed with continuous or unbroken spans, and subject to these conditions: First, that the lowest part of the bridge or bottom chord shall not be less than fifty feet above the city directrix at its greatest span; second, that it shall have at least one span five hundred feet in the clear, or two spans of three hundred and fifty feet in the clear of abutments; if the two latter spans be used, the one over the main steamboat-channel shall be fifty feet above the city directrix, measured to the lowest part of the bridge at the center of the span; third, no span over the water at low-water mark shall be less than two hundred feet in the clear of abutments.

SEC. 13. *And be it further enacted*, That the right to alter or amend this act so as to prevent or remove all material obstructions to the navigation of said river by the construction of bridges is hereby expressly reserved.

Approved July 25, 1866.

C.

AN ACT amendatory of an act approved July twenty-six [five], eighteen hundred and sixty-six, entitled "An act to authorize the construction of certain bridges, and to establish them as post-roads."

Whereas the St. Louis and Illinois Bridge Company, organized under the laws of the State of Missouri, and the Illinois and St. Louis Bridge Company, organized under an act of the general assembly of the State of Illinois, have been consolidated in pursuance of the authority granted to the said Illinois and St. Louis Bridge Company in their act of incorporation, and the authority granted to the St. Louis and Illinois Bridge Company, by an act of the general assembly of the State of Missouri, approved March nineteen, eighteen hundred and sixty-eight: Therefore,

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the company formed by this consolidation under the name and style of the Illinois and St. Louis Bridge Company is hereby recognized and declared to be a corporation by that name, with full power and authority to construct a bridge across the Mississippi River opposite the city of St. Louis, in conformity to the act of which this act is amendatory, with all the rights, privileges, and powers granted and conferred by the several acts of the general assemblies of the States of Illinois and Missouri to the respective companies, by the consolidation of which the said Illinois and St. Louis Bridge Company was formed, and not inconsistent with the provisions of the act to which this act is amendatory: *And provided further*, That in constructing said bridge, there shall be one span of at least five hundred feet clear between piers.

SEC. 2. *And be it further enacted*, That the said corporation may execute a mortgage and issue bonds payable, principal and interest, in gold; and their bridge across the Mississippi River and approaches thereto, when constructed, shall be a post-road to carry the mails of the United States, and enjoy the rights and privileges of other post-roads.

SEC. 3. *And be it further enacted*, That said corporation may hold their meetings in either the State of Illinois or the State of Missouri, as the board of directors may elect, and the directors may be citizens of any of the United States; and said corporation may sue and be sued in any circuit court of the United States: *Provided*, That nothing in this act or in any previous legislation affecting the premises shall be so construed as to deprive the legislatures of the States of Illinois and Missouri of the right to regulate the tolls and fares which may be charged by said company for the use of such bridge: *Provided further*, That the tolls now fixed by the legislatures of Illinois and Missouri shall not be increased.

Approved July 20, 1868.

G.

RECORD OF THE STAGE OF WATER IN THE MISSISSIPPI RIVER AT ST. LOUIS, COMPILED FROM THE OFFICIAL REPORTS OF THE CITY ENGINEER.

NOTE.—The following tables show on how many days of each month the river-surface was at or above the indicated heights above low-water.

High-water of 1844 reads on the gauge	+ 7.57
High-water of 1851 reads on the gauge	+ 2.58
High-water of 1858 reads on the gauge	+ 3.29
Low-water of 1860 reads on the gauge	- 33.21
Low-water of 1863 reads on the gauge	- 33.81

The zero of the gauge is a bench-mark at the foot of Walnut street, which, when established, was supposed to be at high-water mark. This bench-mark is called the city directrix, and all ordinary stages of water are below it, and have minus readings on the gauge. The directrix is 7.58 feet below the high-water mark of 1844.

SPECIAL HIGH-WATER RECORDS.

Incomplete records of the high-water of 1844, 1851, and 1858, are found in the office of the city engineer, which are consolidated in the following table:

Year.	Month.	No. of days on which observations were taken.	Height in feet above low-water.		
			30.	35.	40.
1844..	June 21 to July 13	23	23	21	6
1851..	June 3 to July 21	49	46	24	0
1858..	June 8 to June 23	16	16	8	0

Month.	Height in feet above low-water.						
	5.	10.	15.	20.	25.	30.	35.
1861.							
January							
February	15	13					
March	31	31	27				
April	30	30	30	11			
May	31	31	31	13	3		
June	30	30	30				
July	31	31	23	5			
August	31	9					
September	30	26					
October	31	16					
November	30						
December	24						
Total days in the year	314	217	141	29	3		
1862.							
January	16	8					
February	28	1					
March	31	18	13				
April	30	30	30	28	19	9	
May	31	31	31	31	12	1	
June	30	30	30	10			
July	31	31	31	12			
August	31	31	3				
September	30	26					
October	31	31					
November	30	2					
December	28	4					
Total days in the year	347	243	138	81	31	10	
1863.							
January	31	25	2				
February	28	20	13				
March	31	31	20				
April	30	30	11				
May	31	31					
June	30	18					
July	31	6					
August	31	9					
September	23						
October							
November	12						
December							
Total days in the year	278	163	46				

Month.	Height in feet above low-water.						
	5.	10.	15.	20.	25.	30.	35.
1864.							
January.....	23						
February.....	29						
March.....	31	10					
April.....	30	21	6				
May.....	31	29	13				
June.....	30	24					
July.....	31	24					
August.....	19						
September.....							
October.....							
November.....	7						
December.....	19						
Total days in the year.....	250	108	19				
1865.							
January.....	16	3	1				
February.....	31	31	19	1			
March.....	30	30	30	12	1		
April.....	31	31	22	1			
May.....	30	30	11				
June.....	31	31	31	9	4		
July.....	31	31	31	17	2		
August.....	30	30	6				
September.....	31	26					
October.....	30	19					
November.....	31	3					
December.....							
Total days in the year.....	322	265	151	40	7		
1866.							
January.....	31	25	4				
February.....	28	9					
March.....	31	31	19	3			
April.....	30	30	25	13	9		
May.....	31	31	31	21			
June.....	30	30	30	4			
July.....	31	31	28				
August.....	31	31					
September.....	30	30	10	4			
October.....	31	17	5				
November.....	30	18					
December.....	31	9					
Total days in the year.....	365	292	152	45	9		
1867.							
January.....	22						
February.....	28	20	13	11			
March.....	31	31	21	2			
April.....	30	30	24	17	14		
May.....	31	31	31	25	7		
June.....	30	30	30	30	8		
July.....	31	31	31	31	17		
August.....	31	31	21				
September.....	30	12					
October.....	31						
November.....	30						
December.....	7						
Total days in the year.....	332	216	171	116	46		
1868.							
January.....	7						
February.....	17						
March.....	29	20	13				
April.....	30	30	14	2			
May.....	31	31	31	19			
June.....	30	30	18				
July.....	31	31	12				
August.....	31	2					
September.....	30						

Month.	Height in feet above low-water.						
	5.	10.	15.	20.	25.	30.	35.
October	31						
November	30	15					
December	27						
Total days in the year	324	159	88	21			
1869.							
January	31	20					
February	28	21	4				
March	31	17					
April	30	30	24	1			
May	31	31	31	1			
June	30	30	30	21			
July	31	31	31	31	30		
August	31	31	31	8	2		
September	30	30	30	3			
October	31	31	29				
November	30	30					
December	31	15					
Total days in the year	365	317	210	65	32		
1870.							
January	31						
February	28						
March	31	15	4				
April	30	30	30	30	6		
May	31	31	31	14			
June	30	30	12				
July	31	21					
August	31	2					
September	30	17					
October	31	27					
November	30	16	8				
December	31						
Total days in the year	365	189	85	44	6		
1871.							
January	21	7					
February	28	20	5				
March	31	31	31	9			
April	30	30	7				
May	31	31	21				
June	30	30	8				
July	31	23					
August	31						
September	9						
October							
November	16						
December	18						
Total days in the year	276	172	72	9			
1872.							
January	15						
February	29	1					
March	31	2					
April	30	30	16				
May	31	31	26	10			
June	30	30	30	19			
July	31	31	31	4			
August	31	29	8				
September	30						
October	30						
November	23						
December	5						
Total days in the year	316	154	111	33			
1873.							
January	31	11					
February	28	13	1				
March	31	20	10				
April	30	30	25	13	6		
May	31	31	31	15			
June	30	30	30	30	2		
Total days in the first six months of the year	181	134	97	58	8		

H.

DURATION OF EACH STAGE.

This table shows the number of days in each year during which there were not less than the following heights above low-water.

Year.	5 feet.	10 feet.	15 feet.	20 feet.	25 feet.	30 feet.	35 feet.
1861	314	917	141	29	3	.....	.....
1862	347	943	138	81	31	10	.....
1863	278	163	46	.....	.....	.....	.....
1864	250	108	19	.....	.....	.....	.....
1865	329	965	151	40	7	.....	.....
1866	365	999	152	45	9	.....	.....
1867	339	916	171	116	46	.....	.....
1868	394	159	88	21	.....	.....	.....
1869	365	317	910	65	32	.....	.....
1870	365	189	85	44	6	.....	.....
1871	276	172	72	9	.....	.....	.....
1872	316	154	111	33	.....	.....	.....
1873, first six months	181	134	97	58	8	.....	.....
Average duration of each stage	322.8	910.3	118.5	43.3	11.4	0.8	.....
Corresponding space under center of bridge.	83.57	78.57	73.57	68.57	63.57	58.57	.....
Corresponding space available allowing a width of 174 feet	78.57	73.57	68.57	63.57	58.57	43.57	.....

K.

NAMES AND DIMENSIONS OF SOME OF THE LARGEST BOATS EMPLOYED ON THE MISSISSIPPI RIVER, AND WHICH PASS THE CITY OF ST. LOUIS, MO.

Passenger-packets.

Names of boats.	Top of pilot-house above water.	Top of texas above water.	Top of cabin above water.	Top of chimneys above water.	Length of boat.	Width over all.
	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.
James Howard	69	.....	.....	104	.....	79 4
Thompson Dean	67	46 4	36 8	91 4	306	.....
Phil. Sheridan	65 8	36 2	27 8	72 8	222	.....
J. H. Johnston	65 8	36 2	27 8	72 8	246	.....
Andy Johnson	63 2	36 2	27 8	80 8	273	.....
Jo. Kinney	62 3	35 9	27 9	75 9	241 6	.....
Tom Jasper	62	37 6	27 10	72	257	.....
Richmond	61 2	45	35 5	97 5	340	.....
John A. Scudder	59 7	43 10	34 2	94 2	306	.....
Dexter	59	44	33 10	87 10	340	.....
Grand Tower	58 4	41	32	90	276	.....
Lucy Bertram	58 4	34 4	26 2	76 2	250	.....
Continental	57	40 6	31 4	83 4	268	.....
City of Helena	56 10	40 4	31 4	93 4	277	.....
Pauline Carroll	56 8	42	32	88	266 6	.....
Belle of Memphis	56	40	31	93	273	.....
Exporter	55	39	32	77	232	.....
City of Chester	55	38 10	30	84	250	.....
Henry Arnes	54 10	39 9	31	83	305	.....
Julia	54 8	34 8	27 4	83 4	243 6	.....
Emma C. Elliott	53 8	38	28 3	82 3	232	.....
Commonwealth	53	39	30	84	264	.....
Illinois	52 9	35 3	27 8	67 8	210	.....
Susie Silver	52 4	37 2	28	86	265	.....
John Kyle	52 1	38 3	31 1	83 1	299	.....
P. W. Strader	51 8	35 8	26 8	80 8	233	.....
City of Quincy	50 10	36 10	29 6	79 6	236	.....
Rob Roy	50 4	36	27 4	79 4	273	.....
Lake Superior	49 9	35	27 8	76 8	245	.....
Clinton	49 9	35 11	27 8	73 8	253	.....
Northwestern	46 7	29 11	21 7	65 7	257	.....
Fanny Keener	46 5	33 11	25 7	67 7	206	.....

Great Republic, not in port, higher than that of any on this list, and runs to sugar-refinery and elevator above the bridge.

Tow-boats.

Names of boats.	Height of pilot-house above water.	Height of chimneys above water.	Length over all.	Width over all.
	<i>Ft. in.</i>	<i>Ft. in.</i>	<i>Ft. in.</i>	<i>Ft. in.</i>
Mohawk.....	64 3	78 3	189 0	35 0
Future City.....	51 0	75 5	222 0	46 4
St. John.....	37 8	59 0	200 0	44 0
Atlantic.....	37 8	64 8	191 0	33 5

Crescent City, Mary Alice, and Bee, not in port, are as high as, and two of them are higher than, those given in the above list.

Ferry-boat East St. Louis.

Height of pilot-house above water	<i>Ft. in.</i> 40 2
Height of chimneys above water.....	80 6

Belleville, Cahokia, Charles Mulliken, Edwardsville, Ed. C. Wiggins, Louis V. Bogy, & C. Christy, Springfield, America, Bunker Hill, Lavina Marie, and Submarine, No. 13, are near or about the same measurement as the East St. Louis.

JAMES MCCORD,
Secretary of Boatman's Association of St. Louis, Mo.

Supplementary report of Board of Engineers.

ENGINEER OFFICE, UNITED STATES ARMY,
St. Louis, Mo., January 31, 1874.

GENERAL: The Board of engineer officers constituted, by Special Orders No. 169, dated War Department, Adjutant-General's Office, Washington, D. C., August 20, 1873, to examine and report upon the Illinois and St. Louis Bridge across the Mississippi River, at St. Louis, Mo., having been reconvened by its president, under instructions from the Chief of Engineers, United States Army, dated November 25, 1873, met at St. Louis, Mo., January 14, 1874, to consider and report upon the survey and estimates made in pursuance of the recommendation of the Board in their previous report and also to consider and report upon certain documents submitted to them by the Chief of Engineers, United States Army, under date of December 30, 1873. These documents consisted of a review of the previous report of the Board by Mr. James B. Eads, chief engineer of the Illinois and St. Louis Bridge; and of two affidavits made by William Taussig, chairman of the executive committee of the bridge company, and John W. Noble, its attorney, setting forth that, in the investigation made by the Board at its first meeting, the bridge company had been unfairly treated.

The Board were also directed by the Chief of Engineers, United States Army, under date of January 10, 1874, to investigate and explain certain discrepancies between the official report of the Board as received at the War Department, and the copy of the same published by the St. Louis papers and quoted by Mr. Eads in the review already mentioned.

Having performed the duties assigned them, the Board have the honor to submit herewith their report, to which are appended the following maps and documents:

LIST OF APPENDIXES.

A. Map showing the cut around the last abutment of the Illinois and St. Louis Bridge over the Mississippi River, at St. Louis, Mo., as proposed by the Board of United States engineer officers, convened by Special Orders No. 169, dated War Department, Adjutant-General's Office, Washington, D. C., August 20, 1873.

B 1. Letter of Wm. Taussig, chairman of the executive committee of the Illinois and St. Louis Bridge Company, to the honorable Secretary of War, dated December 19, 1873, inclosing affidavits, &c. (The three following documents were inclosed in the above.)

B 2. Review of the first report of the Board by Jas. B. Eads, chief engineer Illinois and St. Louis Bridge. (The appendix to this review is omitted.)

B 3. Affidavit of John W. Noble, addressed to the honorable Secretary of War.

B 4. Affidavit of Wm. Taussig, addressed to the honorable Secretary of War.

C. Personal statement of Col. J. H. Simpson, Corps of Engineers, senior member of the Board.

D. Personal statement of Maj. G. K. Warren, Corps of Engineers.

E. Letter addressed by the Board to Mr. Eads, dated January 14, 1874.

F. Reply by Mr. Eads to the above letter, dated January 15, 1874.

PLANS AND ESTIMATES.

The plan sketched by the Board in their first report contemplated a canal, or rather an open cut, behind the east abutment of the bridge, giving a clear width of water-way of 120 feet at the abutment; the shore-side of this cut to be laid out on an easy curve, joining the general shore-line about 500 feet above, and 300 feet below the bridge; the river-side to be entirely open, but the shore-side to be revetted vertically with stone or crib work to a height of 5 feet above extreme high water; this wall to be provided with ring-bolts and posts, to enable boats to work through the cut with lines; finally to span the opening thus formed by a draw-bridge, giving a clear span of 120 feet in width.

The survey made in accordance with the recommendation of the Board developed the necessity for several modifications, which are set forth in the accompanying map, (Appendix A.)

The cut, as shown, is 1,400 feet long, extending an equal distance above and below the bridge. The bottom is 40 feet below the St. Louis City directrix, or 6 feet below extreme low water. The shore side has a slope of one horizontal to one vertical, and is paved with stone, the foot of the slope being secured by sheet-piling.

The pivot pier rests on a square bed of concrete, with piles underneath, the area covered by the concrete being inclosed by sheet-piling.

The draw-span is 308 feet long, one end resting on the east abutment, and the other on a new pier built on Front street, in East St. Louis.

A combination of wooden cribs, filled with stone and floats, rising and falling with the water-surface, is designed to prevent boats from coming in contact with the draw when opened.

Finally, ring-bolts on the levee-slope, and attached to the cribs, are designed to enable boats to work through the cut with lines.

ESTIMATE.

Land damage :

1,400 linear feet river-front, less 100 feet owned by bridge company, 1,300 feet, at \$300..... \$390,000 00

Removing present approaches :

Taking down masonry of present eastern approach, 10,624 cubic yards masonry, at \$3..... \$32,052 00

Removing foundation of eastern approach, four caissons, at \$1,000..... 4,000 00

Foundation tower-pier..... 2,000 00

38,052 00

Canal:

Earth excavation, (dredging,) 108,620 cubic yards, at 30 cents..	\$32,586 00	
Paving side-slope, 5,924 square yards, at \$1.50.....	8,886 00	
Sheet-piling at foot of slope, 1,471 linear feet, at \$3.....	4,413 00	
		\$45 885 00

Pivot-pier:

Excavation for foundation and pumping, 11,500 cubic yards, at 90 cents.....	10,350 00	
Concrete, 749.555 cubic yards, at \$10.....	7,495 55	
Sheet-piling, 244 linear feet, at \$10.....	2,440 00	
239 piles, at \$20.....	5,780 00	
Masonry of pier, 3,620.65 cubic yards, at \$18.....	65,172 74	
		91,238 29

Draw pier:

Excavation for foundation and pumping, 300 cubic yards, at 75 cents.....	225 00	
Concrete, 200 cubic yards, at \$10.....	2,000 00	
Masonry, 800 cubic yards, at \$18.....	14,400 00	
		16,625 00

Cribs:

300,700 feet (board-measure) of lumber, at \$40 per M.....	12,028 00	
2,000 cubic yards stone, at \$1.50.....	3,000 00	
6,000 cubic yards excavation, (dredging,) at 30 cents.....	1,800 00	
		16,828 00

Floats:

106,000 feet (board-measure) lumber for floats, at \$50 per M....	5,300 00	
20,000 feet (board-measure) lumber for platforms and guides, at \$40.....	800 00	
30 piles for platforms, at \$25.....	750 00	
20,000 pounds iron, (bolts, spikes, &c.), at 8 cents.....	1,600 00	
		8,450 00
Miscellaneous iron-work—ring-bolts, &c.....	1,500 00	
Repairs to levee.....	5,000 00	

Draw-span:

308 feet long; width, &c., to correspond with present structure.....	225,000 00	
--	------------	--

Total.....	838,578 29	
Contingencies, 10 per cent.....	83,857 83	
		922 436 12

Annual expenses:

Labor, operating draw, &c.....	5,000 00	
Repairs to canal.....	10,000 00	
Total.....	15,000 00	
The above (\$15,000) capitalized, at 6 per cent.....	250,000 00	
Grand total.....	1,172,436 12	

This plan does not give promise of all the accommodation to navigation that the steamboat-men and our own judgment deem necessary, and the comments of the bridge company's agents show that it is exceedingly distasteful to them, and, as they hold, quite inadmissible. Its cost will, moreover, be so great that it is desirable to consider whether the difficulty might not be more effectually met without involving a much larger expenditure.

Several plans have been proposed. One of these, if practicable, seems more desirable than the canal. It consists in buttressing the west pier, so as to enable it to resist the thrust of the loaded central arch, then removing the west arch and substituting for it a truss with horizontal chord, or else a pivot-draw as long as can be operated. The space remaining in the latter case would be filled by a short span.

Another plan would be to buttress the east and west piers and re-

move the center arch, substituting for it a straight-chord truss, and at the same time increasing the gradient of the railway-track as much as possible. This plan would give more clear headway than the other.

The trusses with straight, continuous, horizontal chords would not interfere with the passing on the bridge, and would be less of an obstruction to navigation than the present ones.

The draw, located as proposed, would undoubtedly be better for navigation than the canal and draw around the east abutment, and it would not obstruct the St. Louis landing. It would, however, be objectionable, as all draws must be, to travel on the bridge.

All these projects would involve as much or greater expense than the one already estimated for, and would probably be objected to by the bridge company, not only on this account, but also because they would destroy the symmetry of the bridge.

It has always been held that navigation should never be subjected to injury from bridges that reasonable expenditure and engineering skill could avoid. This bridge, though admirable in some engineering features, is so faulty in its relations to navigation, that, if no acceptable modification can be made, then, in our opinion, it should be entirely reconstructed.

The simplest plan of doing this, involving no new masonry, would be to remove all three arches, and substitute for them horizontal trusses at the same grade as the railroad. This is the structure apparently intended by law. This change could be made entirely satisfactory to the river navigation by, at the same time, raising the bridge about 27 feet. The abandonment or modification of the present approaches would result from this change, but is one of the unavoidable difficulties of changing this structure.

CHANGES IN THE ORIGINAL REPORT.

A letter from the Chief of Engineers, of January 10, 1874, called the attention of the Board to the fact that their report, as published by the St. Louis papers, and as quoted by Mr. Eads in his review, did not correspond in several respects with the official copy on file in the War Department.

As printed by the papers, two paragraphs read as follows :

A large portion of the St. Louis river-front is above the bridge, and several elevators, a sugar-refinery, and other similar buildings, are already located above it. These could not safely be reached by the large boats during high stages, and much inconvenience, &c.

The steamboatmen have stated to the Board, &c., by providing machinery capable of opening and closing the draw with any desired rapidity. They think, moreover, that it will only be in exceptional cases that boats will desire to pass through this draw, so that the delays to trains from this cause will not be excessive.

In the official report these paragraphs read as follows :

A large portion of the St. Louis river-front is above the bridge, and several elevators, a sugar-refinery, and other similar buildings, are already located above it. These could not safely be reached during high stages by the large boats navigating the lower river, and much inconvenience, &c.

The steamboatmen have stated to the Board, &c., by providing machinery capable of opening and closing the draw with any desired rapidity. The use of this draw by the boats will be only in cases of necessity; and the inconvenience which this use may occasion to travel on the bridge, there seems no course left but to submit to.

These alterations were made by one of the members of the Board, to whom the report had been forwarded for signature, and the recorder

was duly notified. This officer was at the time absent from St. Louis, so that the senior officer was not notified of the changes made until after the report had been made public. The official copy received by him from Washington was by instructions at once forwarded to the bridge company, and the representatives of the press were given a retained copy of the report as it left St. Louis. Why Mr. Eads, in his review, used this incorrect copy instead of the official one furnished him, the Board are unable to state.

They wish it, however, to be understood that the alterations noted were such as meet with their entire approval, and they desire to call attention to a foot-note, which they have added to the original report, to explain more clearly their views on the subject of dropping through the bridge by means of lines, a carelessly worded sentence in the report having given rise to a misconception of their meaning, as noted further on in their reply to Mr. Eads's review.

REPLY OF THE BOARD TO MR. EADS'S REVIEW OF THEIR FIRST REPORT.

(For this review see Appendix B 2.)

As the review of Mr. James B. Eads, chief engineer of the bridge company, is one of the documents which have been referred to the Board, they make the following reply to such portions of it as seem to require an answer:

Mr. Eads commences with a philological disquisition on the meaning of the word *expert*. As this term was not used by the Board, but is quoted from a private conversation with the honorable Secretary of War, who is presumed to be acquainted with the character and ability of the officers of the Army, it is hardly necessary to follow Mr. Eads in his comments on this subject.

The question of the adaptability of certain forms of bridges to the wants of navigation is one with which all the members of the Board are familiar from several years' service in improving western rivers; in which service they have been compelled to study the management of steamboats in narrow channels, under all circumstances of wind and weather.

In addition to this general experience, the majority of the members of the present Board composed the Board on all the bridges over the Ohio River, and one or more of the members have been on every engineer Board convened since the war to examine western-river bridges.

This matter of so arranging bridges that they shall not be unnecessary obstructions to navigation, has thus become a speciality with the members of the Board, and from the success that has thus far attended their efforts to harmonize the two opposing interests, they feel justified in considering themselves as better informed on this special subject than those whose engineering knowledge and experience are confined to a single bridge, or than such steamboatmen as seldom, if ever, take their boats above the bridge in question.

Mr. Eads goes on to state that the opinions of the Board must bear the crucial test of experience. With this they fully agree, and are quite willing to meet him on that ground. Although their report has been published in the newspapers, (with some errors, however, due to copying the first draught, which had been somewhat changed,) and has been subjected to much unfair criticism, been held up to public ridicule, and an erroneous public sentiment created by appeals to local interest, the members of the Board have felt it improper for them to reply. Now, however, that the matter has been recommitted to them, the Board take this opportunity to comment upon the criticisms that their report has called forth.

HEIGHT OF STEAMBOAT-CHIMNEYS.

Mr. Eads quotes from the report of the Board :

The apparently unreasonable height and size of the chimneys in general use on these (western river) steamboats are really essential to secure a good draught to the furnaces and economical combustion of fuel. Artificial means to produce the same end are generally very expensive and often ineffective.

He then goes on to state :

Nowhere has the economy of fuel been so closely studied as in the construction of ocean-steamers.

In this statement Mr. Eads is entirely in error. Economy in fuel has been chiefly studied in connection with land-engines, especially those used for pumping. Here there is no limit to the size that can be given to the boilers, and by using very large evaporating surfaces and slow combustion, great economy in fuel has been attained.

The mechanical effect due to the combustion of a pound of coal, generally expressed by the number of pounds raised one foot high in a minute, is alone considered in this case, the time required for combustion being immaterial.

But if from any cause the size of boiler is restricted, while the same amount of mechanical effect is required, it is manifest that the element of time must be considered.

For instance, suppose an engine to be supplied with steam by a boiler of such capacity that the necessary amount of water can be evaporated by burning 5 pounds of coal per square foot of grate per hour. Now, suppose the engine to be replaced by another requiring double the previous amount of steam, the boiler remaining unchanged, other things being equal, it is clear that the boiler can only accomplish the work required by burning 10 pounds of fuel per square foot of grate per hour, instead of 5 pounds, as in the previous case. In practice the amount would be greater, so that economy of fuel has been sacrificed to efficiency in steam generation.

To drive large ships at high rates of speed requires powerful engines and boilers, while the room allowed for the machinery is kept as small as possible. Marine boilers are therefore necessarily very compactly built, and maintain a high rate of combustion.

In their construction efficiency in supplying steam with sufficient rapidity is the ruling consideration. Economy of fuel, while still of course important, must and does give way to it.

Artificial means are seldom used on them to produce a draught, and although the largest ones consume much more fuel per day than any Mississippi steamer, none of their chimneys approach the height of some of those on the river.

The statement that "the largest ones consume much more fuel per day than any Mississippi steamer," is certainly undeniable. As the engines of the larger ocean-steamers work up to six or seven thousand horse-power, while the largest ones on the Mississippi probably never run higher than 3,000, it is not surprising that the fuel consumption per day is greater in the former case.

If, however, Mr. Eads refers to the rate of combustion—that is, to the number of pounds of coal burned on a square foot of grate per hour—then he is again in error. On ocean-steamers this rate is from sixteen to twenty-five pounds, while on western-river boats it runs from twenty to fifty pounds.

The next statement, that "none of their chimneys approach the height

of some of those on the river," is specious and deceptive as well as erroneous.

Persons who judge the height of an ocean-steamer's smoke-stacks from that proportion of them which they see projecting above the upper deck, may well infer that this height is small when compared with that of the chimneys of some of our river-boats.

But it must be borne in mind that on the ocean-steamer the boilers and furnaces are located deep down in the hold, so that a large portion of her chimneys are hidden by the hull, and the actual height, measured from the grates to the top of the chimneys, may be very respectable. Still this height must always be limited, first by the depth of hold, and secondly by the height to which it will be safe and expedient to carry the chimneys above the upper deck. A very great projection would cause much resistance during head winds, and the chimneys would be liable to be rolled overboard in heavy weather.

The Board append a table in which are given the heights of the smoke-stacks of a number of ocean-vessels both large and small. These dimensions are taken from Scott, Russell, and Rankin's works on ship-building. In addition to the examples given in the table, they would state that on the large vessels engaged in the transatlantic trade, this height is from 60 to 70 feet.

They also append a table giving the height above the grates of the chimneys of a number of river-boats frequenting this port, which were selected by the river-men as an argument against the small height of the bridge, and hence may be considered extreme cases. From this information it will be seen that the chimneys of the James Howard, the largest boat on the river, are of the same height as those of the Great Eastern, the largest boat on the ocean, and that 65 feet, the average height for large ocean-vessels, *does approach* the height of a good many of the chimneys used on the river.

Still, their height is generally less, and, as Mr. Eads states, they do not usually require artificial draught. Presumably the drift of this statement is, that as the short chimneys on marine boilers give a natural draught, the higher chimneys on river-boilers are unnecessarily high.

To decide this question, it will be necessary to refer to the laws which govern the combustion of fuel. To effect this combustion a certain number of pounds of air must be supplied to the furnace for each pound of coal or other combustible burned therein. This air may be mechanically forced into the furnace by a fan or blowing-machine, or it may be forced in by the excess in density of the external air over that of the gases in the chimney. This excess of density may be caused solely by the rarefaction and constant expansion of the gases by the heat of the furnace, and in this case the draught is called natural. The same effect may be produced by exhausting or drawing out the gases by a fan or by driving them out by a jet or blast of steam.

The velocity of a natural draught depends upon the head produced, and this is equal to the difference in weight between a chimney full of hot gas and an equivalent bulk of the external air.

This difference, or head, thus varies with the temperature of the gas; hence two chimneys of equal sectional areas, but of unequal heights, will give the same draught if the temperatures of the gases contained in them are inversely proportional to the heights.

For instance, the draught produced by a chimney 100 feet high in which the gases have a temperature of 600° may be produced in a chimney 50 feet high and of similar sectional area, provided the gases are heated up to $1,200^{\circ}$.

Sea-going vessels.

Name.	Dimensions.			Smoke-stacks.				Number of boilers.	Mean pressure of steam.	Number of furnaces.	Total area of dry-grate in boilers.	Heating-surface.	Indicated horse-power.	Remarks.
	Length on load-water line.	Extreme breadth.	Depth at side.	Free board.	Number.	Diameter.	Height of top above deck.	Height of top above grates.						
Great Eastern	Feet. 680	Feet. 118	Feet. 58	Feet. 28	5	Feet. 6 5-6x5	Feet. 44	Feet. 96	10	112	Sq. feet. 9,100	Sq. feet. 8,716	7,532	Stacks, oval section.
Warrior	330 1-6	54 1-6	43	11 7	6	8	17	60	8	40	1,768	.....	5,469	Iron-clad screw-frigate, royal navy, (between perpendiculars.)*
Ulster	337	66 1/2	21	8	4	6	32	48	8	15 1/2	677	.....	4,751	Holyhead royal Irish mail.
Munster	337	66 1/2	20	8	2	7 1/2	23 1/2	45	8	48	.....	.....	.....	French Brasill line, (height top above deck-house.)*
Gulienne	305	64	25	8 27	1	7 1/2	20 1/2	52	4	16	.....	.....	.....	Royal steam-yacht.
Victoria and Albert	300	67 1/2	28	12	2	6	34	53	4	24	.....	.....	.....	Blockade-runner, (between perpendiculars.)
Hop	281	57	15	10	3	6	38	49	4	30	412	9,431 4	1,684	Australian passenger, screw.
Victoria	281	38	27 8-12	10 5-24	2	5 1/2	20	50	4	15	20	412	.....	Mediterranean passenger.
Pacific	245 1/2	54	25 8-12	13 8-12	2	5	45	67	4	18	20	430	1,684	Blockade-runner, (free board when light.)*
Iona	245	44	11 1/2	7 7-12	2	5	31	35 1/2	2	10	206 6	4,287	.....	Screw-corvette, royal navy.
Highflyer	190	36 1/2	24	7 7-12	2	4 1/2	16	36	2	13	169	4,288	.....	Screw.
Irish Trader	188 1/2	43	14	5 8-12	2	3 1/2	20	41	2	.....	126	.....	754	Paddle-dispatchboat, royal navy.
Recruit	178	43	10 8-12	3 8-12	2	3	26 1/2	32 1/2	4	.....	.....	.....	.....	

* On the large steamers of the Cunard, White Star, National, and other transatlantic lines, the height of smoke-stacks above the grates is from 60 to 70 feet.

† About.

Height above grates of the chimneys of a number of steamboats frequenting the port of St. Louis, Mo.

	<i>Ft. in.</i>		<i>Ft. in.</i>
James Howard	96	East St. Louis	72 6
Richmond	89 5	Rob Roy	71 4
John A. Scudder	86 2	City of Quincy	71 6
City of Helena	85 4	Mohawk	70 3
Belle of Memphis	85	Exporter	69
Thompson Dean	83 4	Lake Superior	68 8
Grand Tower	82	Lucy Bertram	68 2
Pauline Carroll	80	Jo. Kinney	67 9
Dexter	79 10	Future City	67 5
Susie Silver	78	Clinton	65 8
City of Chester	76	Phil. Sheridan	54 8
Commonwealth	76	J. H. Johnston	64 8
Continental	75 4	Tom Jasper	64
Julia	75 4	Illinois	59 8
John Keyle	75 1	Fanny Keener	59 7
Henry Ames	75	Northwestern	57 7
Emma C. Elliott	74 3	Atlantic	56 8
Andy Johnson	72 8	St. John	51
P. W. Strader	72 8		

Now, in the types of boilers used on ocean-vessels, the flues or tubes through which the gaseous products of combustion pass, on their way from the furnace to the chimney, are always short; the whole distance from furnace to chimney rarely exceeding 15 feet, and being generally less. On western-river boilers this same distance varies from 40 to 80 feet; therefore it is evident that, in this latter case, the gases on their way to the chimney will be longer in contact with cooling-surfaces, and will finally reach the chimney with a much lower temperature than would be the case in the short-flued marine-boiler. Therefore, from what we have previously stated, it must be apparent that the river-boiler will require a higher chimney than the marine to give the same intensity of draught. So much for ocean-steamers.

As Mr. Eads formerly commanded river-steamboats, and as he has several times crossed the ocean, he certainly should have known that he was comparing things whose conditions were in no way alike. He goes on to state:

The great development of power witnessed every day in locomotives whose chimneys never exceed ten or twelve feet in length is obtained without any artificial means to produce draught except by the escapement of their waste-steam.

To locomotives the same remarks apply as to marine-boilers, but in a still greater degree. Lightness and compactness are the essential qualities, and all questions of economical combustion must be subordinated to the far more important one of efficiency in generating steam rapidly. They are simply machines wherein enormous power is packed away in small compass.

The rate of combustion is from 40 to 140 pounds of coal per square foot of grate per hour, and it must be apparent to any reasonable person that no natural draught could supply the air needed for such rapid combustion unless a chimney of most inordinate dimensions was employed. Even if such could be safely carried on a locomotive, it would be a source of great loss of power from the resistance of the air, and, therefore, the men who first made the locomotive-engine a success wisely decided to produce the requisite draught by artificial means; for the escapement of the exhaust-steam into the chimney, to which Mr. Eads alludes parenthetically, and as though it were of no particular importance, is really the life and breath of the machine, and without its

Sea-going vessels.

Dimensions.			Smoke-stacks.				Number of boilers.	Mean pressure of steam.	Number of furnaces.	Total area of fire-grate in boilers.	Heating-surface.	Indicated horse-power.	Remarks.
Length on load-water line.	Extreme breadth.	Depth at side.	Free board.	Number.	Diameter.	Height of top above deck.							
Feet.	Feet.	Feet.	Feet.		Feet.	Feet.		Lbs.		Sq. feet.	Sq. feet.		
118	38½	58	23	5	6 5-6x5	44	86	10	112	8,100	8,716	7,552	Stacks, oval section.
1-6		43	117	2	8	17	60	8	40	7708		5,469	Iron-clad screw-frigate, royal navy, (between perpendiculars,)*
		21	8	4	9	32	48	8 15½	40	677		4,751	Holyhead royal Irish mail.
		26	8	2	7½	25½	45	8	16				French Brazil line, (height top above deck-house,)*
		25	8 27	1	7 2	35	52	4	34				Royal steam-yacht.
		26	12	2	6	34	53	4	34				Blockade-runner, (between perpendiculars.)
		15	10	2	6	38	49	4	30	413	9,431 4		Blockade-runner, (between perpendiculars.)
		27 8-12	10 5-94	2	5½	20	50	4	30	430	9,507	1,864	Australian passenger, screw.
		25 8-12	13 8-12	2	5	45	67	4	18	30			Mediterranean, passenger.
		11½	7	1	5	21	35½	4	20	208 6	4,287		Blockade-runner, (free board when light,)*
		24	7 7-12	2	4½	16	36	2	19	169	4,258		Screw-corvette, royal navy.
		14	5	3½	3	30	41	2	15	186		754	Screw.
		10 7-12	3 8-12	2	3	30½	33½	4	15	186			Paddle-dispatchboat, royal navy.

The "Star", National, and other transatlantic lines, the height of smoke-stacks above the grates is from 60 to 70 feet.

Height above

James Howard
 Richmond
 John A. Sender
 City of Helena
 Belle of Memphis
 Thompson Island
 Grand Tower
 Pauline Carroll
 Dexter
 Sosie Silver
 City of Chester
 Commonwealth
 Continental
 Julia
 John Keyle
 Henry Ames
 Emma C. Elliott
 Andy Johnson
 P. W. Strader

Now, in the way
 through which the
 from the furnace
 from furnace is
 less. On water

feet; therefore it is
 way to the chimney
 will finally reach the
 would be the case; now
 we have previously
 require a higher draught.
 draught. So much

As Mr. Eads has
 several times stated
 he was comparing
 goes on to state:

The great development
 never exceed ten or twelve
 produce draught

To locomotives
 still greater de
 ities, and all que
 to the far more
 They are simply
 small compass

The rate of
 foot of grate
 that no more
 combustion
 employed. E
 be a source
 herefore, it
 risely de
 or the
 Mr. Eads

which required her
 sing them over-
 thus be detained

ve been paraded
 of the bridge. As
 while to see who
 the best informa-
 correct:
 at-captain of good
 e river below St.

olly unknown to us,
 nboat has recently
 ge he is now out of

New Orleans Packet
 war. He is a recent
 opposed it.

is and New Orleans
 the river since the war.
 since that time.

Mississippi Valley Transporta-
 the river since the war.
 by barges, it is manifestly
 to large steamboats as pos-
 thereby.

be proprietors of the South-
 in 1865, and during this

in the Red River, acting as
 definitely when he left active

have no interest in steamboats,
 commanded one since the war.

proprietors of the Southern Hotel,
 statement, left the river in 1861.
 the close of the war.

merchant, and has not commanded a

when he can get one; but we under-
 on the river.

enced steamboat-captains" does not
 the bridge. Of all the steamboat-
 which is probably second only to New
 Orleans, the bridge authorities have only
 one man, Captain Green, who is now in
 service, entitled to respect, but all the
 the time of the war or are now out
 opinions of ex-river-men on this
 known that before the war the only
 at Eubenville and Wheeling; the only
 were at Clinton and Rock Island;
 on the main Mississippi.
 Mississippi was three hundred and

help the locomotive-engine, as we see it to-day, would be an utter impossibility.

It is a difficult and tedious matter to get up steam on a locomotive, and all round-houses are provided with special means for temporarily lengthening out the chimney until the fire is got fairly burning. After steam is once raised, the fire is kept up by a jet of live steam in the chimney when standing still, and by the fierce blast of the exhaust-steam when in motion.

So much for the facts which Mr. Eads asserts "completely disprove this first statement of the Board."

Before leaving the subject, the Board wish to state that the whole choice between natural and artificial draught is pretty much a matter of dollars and cents. To run or fan a blowing-machine uses up a portion of the available power; to use a steam-blast reduces the power of the engines by back-pressure on the pistons; the steam-jet uses live steam from the boiler, and hence appears the most costly of all; finally, natural draught requires the expenditure of fuel for heating the air in the chimney. Where the choice is unrestricted, the cheapest and most efficient method would naturally be adopted.

It should, however, be stated that while all artificial means of producing draught involves a direct expense, natural or chimney draught *may* be created by heat which would otherwise go to waste. When this is the case, it is unquestionably the cheapest and best, and from the universal preference given it by river-men the Board judge that the proper conditions for its economical use are obtained by them.

Probably the most economical artificial draught is obtained by using the blast of the exhaust-steam. The main objection to its use is the heavy back-pressure which it throws on the engine-pistons when the nozzle-pipe is much contracted. It is also very destructive to the chimneys, as it hastens oxidation. The force of the blast, by detaching rust-scale, constantly presents fresh surfaces to this action. The life of a chimney is shortened fully 50 per cent. by its habitual use.

A very important argument in favor of tall chimneys is afforded by the fact that the sparks thrown out of a short chimney by a powerful draught are a very great source of danger, as hay, cotton, and similar bulky and highly combustible materials form a very important item of river-freight. With a tall chimney the sparks are either extinguished before they reach the top or else are thrown clear of the boat.

The next question discussed by Mr. Eads is the practicability of raising or lowering large chimneys with facility and dispatch. He says that it is perfectly feasible, at an expense of from \$1,000 to \$1,500. This statement may or may not be correct, but there is no proof of it other than the statement itself and a document signed by "thirteen experienced steamboat-captains." As the apparatus recommended is not stated to be in use, and presumably has been invented by Mr. Eads or some friend of his, it must be received with the usual discount due to the statements of inventors.

The real difficulty is not in raising or lowering a *new* chimney at a wharf, but in handling one not new and under the pressure of winds. When chimneys are raised on a steamboat under construction it is done at a favorable time, when there is no wind, and while the chimneys have their maximum strength. When once up, they are secured as firmly as possible by chain-guys, but even this precaution does not prevent them from being occasionally blown overboard. These guys must be cast off before the chimneys can be lowered. They are thus left unsupported, and would probably go overboard if much wind were blowing. There-

fore a boat arriving in windy weather, at a bridge which required her chimneys to be lowered, would either have to risk losing them overboard or else wait until the wind abated, and might thus be detained for days at a time.

The "thirteen experienced steamboat-captains" have been paraded at considerable length as river-men who are in favor of the bridge. As so much is made of their testimony, it may be worth while to see who they are. The following brief descriptions are from the best information we could get, and are believed to be substantially correct:

N. S. GREEN: Steamer Richmond; is a steamboat-captain of good repute, whose business is entirely confined to the river below St. Louis.

JOHN McCLOY: Steamer Continental; is personally unknown to us, but the newspapers have informed us that his steamboat has recently been sold by the sheriff. To the best of our knowledge he is now out of occupation on the river.

N. BOFINGER: President of St. Louis and New Orleans Packet Company; has not commanded a boat since the war. He is a recent convert to the bridge, having until lately strongly opposed it.

JNO. W. CARROLL: Superintendent St. Louis and New Orleans Packet Company; has not been in command on the river since the war. Has been on duty on a wharf-boat in St. Louis since that time.

HENRY C. HAARSTICK: Vice-president Mississippi Valley Transportation Company; has not commanded a boat on the river since the war. As his business is confined to transportation by barges, it is manifestly to his interest to have as many obstructions to large steamboats as possible, provided his tow-boats are not injured thereby.

THEODORE LAVEILLE: Has been one of the proprietors of the Southern Hotel, in St. Louis, since it opened, in 1865, and during this time has not been in command on the river.

J. P. FITZGERALD: Is at Shreveport, on the Red River, acting as steamboat-agent. It is not known to us definitely when he left active service on the river.

DANIEL G. TAYLOR: Is understood to have no interest in steamboats, and has not, so far as we can learn, commanded one since the war.

GEORGE W. FORD: Is one of the proprietors of the Southern Hotel, in this city, and, according to his own statement, left the river in 1861.

BARTON ABLE: Left the river about the close of the war.

J. S. NANSON: Is a commission-merchant, and has not commanded a boat since the war.

P. YORE: Commands steamboats when he can get one; but we understand that he has no regular position on the river.

This record of the "thirteen experienced steamboat-captains" does not make a very satisfactory exhibit for the bridge. Of all the steamboat-men who frequent this port, which is probably second only to New Orleans in the amount of its commerce, the bridge authorities have only been able to produce one steamboat-man, Captain Green, who is now in active service. His opinion is, of course, entitled to respect, but all the others either left the river about the time of the war or are now out of employment. The value of the opinions of ex-river-men on this point may be estimated, when it is known that before the war the only bridges across the Ohio were at Steubenville and Wheeling; the only ones across the Upper Mississippi were at Clinton and Rock Island; and there were none over the Missouri or the main Mississippi.

The nearest bridge on the Upper Mississippi was three hundred and

forty-seven miles above St. Louis, and the nearest one on the Ohio was one thousand and seventy-seven miles distant.

The Board do not think it their province to enter on the question of possible changes in the character of river-vessels. Opinions will differ on such points, and speculations on possible changes are of little value.

Taking the navigation *as it is* and *as it was before the later bridges were built*, it seems reasonable to suppose that the character of construction, which is the result of fifty years' experience, is that which best meets the requirements of the trade which it accommodates. They therefore take for granted that there are sound practical reasons for having elevated pilot-houses and high chimneys.

Mr. Eads entirely misrepresents the position of the Board on the subject of wide and narrow spans. He states that they have come to the following conclusions:

1. Lights placed on an arch 50 feet above high-water are of no greater assistance.

This they maintain to be absolutely true, but nevertheless they recommended the establishment of lights on the bridge because they are of some little service, and therefore they proposed using their help for what it is worth. Something must be done to help find the middle of the span, and although the remedy is an imperfect one, it is yet the only thing that the paltry construction of the bridge will permit, and therefore they recommended it.

2. Greater head-room for passing boats is indispensable.

This they also maintain, and in defense of the proposition they quote Mr. Eads himself. In the report of the proceedings of the congressional convention held in St. Louis in May, 1873, page 50, the following resolution was introduced by Mr. Eads:

Seventh. That the vast commerce depending on the Mississippi River for cheap transportation demands that no artificial obstruction be permitted in its channel, except upon the most urgent necessity, and that no bridge should be authorized across it below St. Louis having spans over the stream of less width than 500 feet, and a clear height of 75 feet above high-water mark should be preserved under the center of the channel-spans of such bridge.

This was his opinion about any future bridge, but he thinks that his own bridge need only be $43\frac{1}{2}$ feet above high-water, and that only at the middle of an arch, a deviation from which exact point might insure the destruction of a passing boat. The excellent principles which he applies to others he is unwilling to have applied to himself. The Board are decidedly of the opinion that either the bridge under question should have been of this height above water throughout the span, or else should have been built with a draw. A more objectionable form than the one adopted could scarcely have been devised.

3. Piers 520 feet apart are too wide to serve as guides.

This sentence, as it stands, conveys a false impression of the meaning of the Board. Piers as wide apart as stated would give ample space for navigation. The true statement of their opinion is that this width is practically useless in the present case, as no boat could approach within 150 feet of either pier on account of the arches, and therefore these piers are useless as guides.

Mr. Eads makes a strong point of one sentence in the report of the Board, which was carelessly written and open to misconstruction, though it is difficult to see how it could have been really misunderstood by persons who profess to be familiar with river navigation.

The sentence read: "In case of wind a boat can be dropped through the opening by lines made fast to ring-bolts in the pier itself." The true meaning of this sentence, as intended, is that in case of a narrow opening, with a clear headway, it would be practicable to extend the piers up-stream for more than the length of a boat, so that before passing through the opening she could round to, make fast to the extension of the pier, and then drop through gradually. This system is adopted at the Louisiana bridge over the Upper Mississippi for passing the draw in windy weather, and a similar method is used at other bridges where the draw is located near the shore. That this use of ring-bolts has often been made on the Upper Mississippi and Missouri was a fact well known to all persons navigating those streams.

Mr. Eads thinks that the Board have not been sufficiently explicit in their reasons for condemning arched bridges over navigable streams. They thought that they had said enough to convince any unprejudiced person, but for his benefit they will repeat their reasons for this statement. They will be based solely on the effect such structures have on navigation.

In determining the height and shape of a bridge, the first point to be settled by those building it is, what shall be the least height of the roadway? The second question is, shall this roadway be supported from above or from below? The latter question will generally be answered by bridge-builders, either way which may seem most convenient and economical. The Board make a definite issue between two bridges with roadways on the same level, one of which is supported from above and has a level bottom chord, and the other is supported underneath by an arch. Both may give the same height for navigation under the center of the span, but the straight-chord bridge allows a boat to pass anywhere under this span without danger, while the arch-bridge compels a boat to pass at the exact central point.

As a practical case, take two bridges built as above, and suppose a boat, whose highest part when chimneys are lowered is just within the clear height afforded, to arrive from up-stream at these two bridges in succession. If she has an inch to spare she can pass with perfect safety under any part of the straight-chord bridge, whether she heads straight down-stream or goes down broadside under the influence of wind or current; but it is self-evident that any attempt under such circumstances to pass the arched bridge might result in the partial or total destruction of the boat, and she would probably go to the bank rather than risk it.

River-steamboats are very high above water, flat-bottomed, and of shallow draught. They have, therefore, little hold on the water, and are easily turned out of their course by the wind. To assume, therefore, that such boats, under all the varying conditions of wind, weather, and currents, can be steered so as to follow a line exactly, would show great ignorance of river-navigation.

The great width of spans given the present bridge is, therefore, practically useless. A narrower span with level chords would be much better, as the piers would always be clear and distinct obstacles, and a boat, under all ordinary circumstances, could avoid them without difficulty, knowing that if she did this she was safe. It would be very different from endeavoring to steer for an illy-defined point, high in the air, with the knowledge that if the exact point were not reached the boat might be wrecked. The least change in the current, and the currents of different stages are seldom exactly parallel, may vitiate the conclusions of the best-informed pilots, and none of them would approach such a dan-

gerous spot without dread. It seems hardly necessary to multiply minor reasons against this form of bridge, as any steamboat-man who would not be convinced by the above would probably continue a skeptic, no matter what evidence were brought before him.

As a practical illustration of the effect of this bridge, we will state that during the few weeks that have elapsed since the arches were closed two ferry-boats have been injured by striking against the iron-work of the bridge. During this time navigation on the upper river has been pretty much suspended by ice and low water, or the number of casualties would probably have been much greater.

Mr. Eads concludes by stating that he alone was the bridge-engineer, and therefore he alone was authorized to speak for the company on engineering matters. As he was said to be in Europe when the Board met, it was manifestly impossible to call upon him for information, and therefore the Board called upon Colonel Flad, the engineer, who has generally been understood to be responsible for the scientific part of the work, and also upon Mr. Katte, who, as the engineer of the contractors for the superstructure, was largely responsible for that part of the work.

Colonel Flad was presented to the Board of engineers by Mr. Taussig, chairman of the executive committee of the bridge company, as the officer authorized to speak for them on matters of engineering, and all the drawings presented to the Board were signed "James B. Eads, per Henry Flad." If the Board misunderstood Colonel Flad, they regret it, but they certainly can recollect of no other objection from him to their proposed modification of the bridge than the one alluded to in their report.

Although great exception has been taken to the report of the Board, and many difficulties in the construction of the lateral cut have been indicated, yet no other remedy for the obstruction to navigation has been proposed by the bridge company. They have contented themselves with stating that the bridge is not much of an obstruction after all.

This is, however, simply a question of fact, and the Board believe that any intelligent man is able to judge in this matter for himself, and that all such who are unbiased by interest or local feeling will come to the same conclusions that they have. If that fact be conceded, it is an inevitable consequence that some change ought in justice to be made. The cost of making the change is something for which the Board are in nowise responsible. It is the inevitable result of a badly-designed bridge.

The Board think it due to themselves to state that the review of Mr. Eads has mainly been based on minor and comparatively unimportant points. The main and essential point that the Board made was that this bridge was a decided obstruction to the navigation which now exists on the Mississippi River, and to prove this they cited figures and dimensions, which have not been contested, and which of themselves prove the extent of the obstruction.

The substance of Mr. Eads's reply is that the majority of river-steamboats must be rebuilt to conform to his bridge.

If a duplicate of this bridge were to be built at Carondelet or Cairo, it would be generally denounced in St. Louis as a great outrage upon her river-commerce, and the Board cannot see why the present bridge is not as serious an obstruction to the commerce of all the cities and towns above St. Louis.

REPLY OF THE BOARD TO THE AFFIDAVITS OF MR. TAUSSIG AND MR. NOBLE.

(See Appendix B, Nos. 1, 3, and 4.)

The affidavits made by William Taussig, member of the Board of Directors of the bridge company, and John W. Noble, acting as attorney and counsel to this company, concerning the proceedings of this Board at its first meeting, addressed to the honorable the Secretary of War, and transmitted to the Board for our [their] information, "and for consideration and report," having been considered by the Board, they submit the following report in regard thereto :

There appears to have been a misunderstanding on the part of the affiants as to the duties of the Board, although the latter did all in their power to explain their understanding of the instructions furnished them, which alone could be their guide. The Board regarded themselves as engineers directed by the orders of a superior officer to examine into certain alleged facts, and did not think it necessary to inquire of anybody regarding matters which were plain to their own observation and reason.

The only facts that were vital to the question were the height, width, and form of the bridge-spans, and the height and general dimensions of the steamboats likely to pass under them. These were all before them.

The Board, however, granted the fullest liberty to all parties to appear before them and make their own statements. There existed from the first a marked difference of opinion between the Board and the affiants; the latter, as shown by their affidavits, holding that such statements were *testimony*, while the Board held that "*testimony is strictly the evidence of a witness given under oath*," and, as they had not the legal right to administer an oath, they could not take testimony.

The Board, therefore, declined to make record of the irresponsible statements which they received, deeming that they, in their own judgment, could rightfully give to each statement the weight it deserved, and that the Secretary of War wanted their opinions on the facts of the case, and not those of irresponsible persons. The Board also, as stated by the affiants, declined to hear counsel on questions of law, that subject not having been submitted to them.

The senior member of the Board duly informed the bridge company of the order directing their meeting, as shown by the paper prepared by him, and which accompanies this report, (Appendix C.) No pains were spared to give that company the earliest notice practicable and to treat them fairly.

The Board, in its hearings, first had before them those who complained of the obstruction of navigation by the bridge. These gave their views, in the words of Mr. Noble, one of the affiants, "concerning the heights of boats, their chimneys, the character of the St. Louis Harbor, the necessity for high pilot-houses and tall chimneys, the comparative safety of raising or lowering steamboat-chimneys, whether they could be raised and lowered at all, whether artificial draught could be used, the expense that would be incurred by preparing chimneys, and the difficulties of piloting boats under the bridge."

The above hardly states the number of questions which were considered; but, taking it as it is, it is evident that a very considerable time was necessary to hear an individual on each point. A large number of persons opposed to the bridge were present and ready to give their views on these points. After hearing several, and finding their statements merely cumulative, in order to save time one of the members of the

Board drew up the memorandum quoted by Mr. Noble, and asked these men if it did not in brief express their opinion as to what constituted a serious obstruction in regard to height. To this they all assented, and wrote their names in pencil upon the memorandum, although such action was not requested by the Board.

The Board then proceeded to hear those river-men that the bridge company brought forward on their side. All present, consisting of Barton Able and George W. Ford, were heard. They were both out of river business, and but little interested in it.

The affiants then stated that they could bring others to make similar statements, if the Board would adjourn till the next Monday or Tuesday, it being then Friday. This was impossible, because the other duties of the members of the Board did not admit of this delay.

The affiants then asked to be allowed to circulate a paper for signature, in opposition to the memorandum drawn up by a member of the Board, to represent the views of those opposed to the bridge. This was objected to by the Board, as they had determined not to take the views of any one that did not appear before them in person, so as to answer the questions they might put to him as to his knowledge of the subject. The senior member specially informed the affiants that any one who appeared in person should be heard.

To avoid any appearance even of unfairness, the memorandum, which had been signed by the river-men, as to what constituted a serious obstruction to navigation, was torn up, and no use was made of it by the Board.

The remark made by Major Warren, and quoted by Mr. Taussig in his affidavit, Major Warren asks to be allowed to make his own explanation of. This he has done in writing, and his statement accompanies this report. (Appendix D.)

Respectfully submitted, by your obedient servants,

J. H. SIMPSON,

*Colonel of Engineers and Brevet Brig. Gen. U. S. A.,
President of Board.*

G. K. WARREN,

Major of Engineers and Brevet Major Gen., U. S. A.

G. WEITZEL,

Major of Engineers and Brevet Major Gen., U. S. A.

WM. E. MERRILL,

Major of Engineers and Brevet Colonel.

CHARLES R. SUTER,

Major of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,

Chief of Engineers, U. S. A.

B 1.

Letter of Mr. Wm. Taussig to the Honorable Secretary of War.

ILLINOIS AND ST. LOUIS BRIDGE COMPANY.

St. Louis, December 19, 1873.

SIR: Inclosed I have the honor to transmit the affidavits of Gen. John W. Noble and of myself, relative to the manner of conducting the investigation by the Board of United States engineers, convened under Special Orders No. 169, War Department, Adjutant-General's Office, Washington, August 20, 1873. These affidavits cover the

grounds of complaint which I had the honor to submit to you personally on behalf of this company, and which you desired me to forward to you.

The pressure of other important business has prevented me from attending to it sooner.

Very respectfully, your obedient servant,

WM. TAUSSIG,
Chairman Executive Committee.

Hon. W. W. BELKNAP,
Secretary of War.

B 2.

Review of the first report of the Board, by Mr. James B. Eads.

ENGINEER'S OFFICE, ILLINOIS AND ST. LOUIS BRIDGE COMPANY,

October, 1873.

To the President and Directors :

GENTLEMEN: The report of a Board of United States engineer officers, dated September 11, 1873, approved by the Chief of Engineers, United States Army, having been referred to me, I respectfully submit on these important papers the following review :

Owing to an inadvertence which occurred in the United States Bureau of Engineers when transmitting to this company the above papers, it was stated that the report had been approved by the Honorable Secretary of War. Fearing such high official sanction might possibly affect the credit of the company, the chairman of your executive committee and myself immediately visited Washington to obtain a recall of this approval until a review of the report could be laid before the Department.*

We learned from the Honorable Secretary that he had not approved the report, and had taken no action on it, and a letter from the Chief of Engineers, addressed to the president of the company, explained and corrected the inadvertence above mentioned.

The order convening the Board directs it "to examine the construction of the St. Louis and Illinois bridge across the Mississippi River at St. Louis, and report whether the bridge will prove a serious obstruction to the navigation of the river; and if so, in what manner its construction can be modified."

I was informed by the Honorable Secretary of War that the Board was convened as "experts to examine the subject, and was not required to take the opinion of others upon it. The report, however, conveys, by its tenor, the evidence that the decision of its members was formed not alone on their own judgment as experts, but also upon the statement of a few of the steamboat-men examined. I was not present, but am reliably informed that the Board refused to receive the rebutting testimony of the company, which, in consequence, has made complaint, through its counsel, to the War Department.†

The report declares that the bridge will be a very serious obstruction to navigation when completed.

The correctness of this decision rests wholly upon the reliability of the testimony received by the Board, and the qualifications of its own members as experts in river navigation. For, manifestly, if the evidence relied upon be untrustworthy, and the members themselves not qualified to act as experts, their opinions, although unanimous and strengthened by the indorsement of the chief officer of their corps, can be of no value whatever. The views of the steamboat-men referred to in the report are shown by the accompanying letters to be wholly incorrect. The first one of these letters is from the Mayor of St. Louis, Capt. Joseph Brown, who commanded several of the largest steamers on the river, and the second one is from a number of other well-known, highly respected, and skillful commanders, who have also navigated some of the largest steamers afloat. Several of these gentlemen are to-day deeply interested in the largest ones; hence they would be peculiarly injured if the bridge were really a serious obstruction. Not one of these gentlemen has a dollar of interest in the bridge.

The height necessary for the pilot, and the difficulty of steering through the central part of the arch, are the only two questions on which the Board seemed to think it necessary to support its own views by reference to the assertions of steamboat-men. It will be hereafter seen by quotations from these letters that on these two points their statements were wholly unreliable. This fact established, it remains to examine what value should attach to the opinions of the distinguished experts themselves.

* The report of the Board, with the approval of the same by the Chief of Engineers, will be found in the Appendix.

† See affidavits of Dr. William Taussig and General Noble in Appendix.

Webster defines an "expert" as "one who has skill, experience, or peculiar knowledge on certain subjects of inquiry in science, art, trade, or the like." I believe this definition is generally accepted as correct. The possession of either "skill" or "experience" in steam navigation on rivers can only be the result of individual practice, and as these gentlemen have not had this, it cannot be claimed that they have either skill or experience. Hence their qualifications must necessarily rest solely upon the possession of "peculiar knowledge" of river navigation, and this, for the same reason, cannot be practical knowledge.

Their distinguished reputation would, however, lead the public to infer that they had carefully studied the various problems of river navigation, and that their superior scientific acquirements made the correct solution of these questions so simple that practical knowledge was unnecessary. It will be presently seen whether the views of the Board justify this inference. The opinions of purely scientific gentlemen on questions of commerce, navigation, and the like, must, when challenged, bear the crucial tests of experience, or they will fail to command public confidence. The report declares: "The apparently unreasonable height and size of the chimneys in general use on these steamboats are really essential to secure a good draught to the furnaces and economical combustion of fuel. Artificial means to procure the same end are generally very expensive and often ineffective."

Nowhere has the economy of fuel been so closely studied as in the construction of ocean-steamers. Artificial means are seldom used on them to produce a draught, and although the largest ones consume much more fuel per day than any Mississippi steamer, none of their chimneys approach the height of some of those on the river. The great development of power witnessed every day in locomotives whose chimneys never exceed 10 or 12 feet in length is obtained without any artificial means to produce draught, except by the escapement of their waste steam. These facts completely disprove this first statement of the Board.

The report says: "Although it is a comparatively easy task to lower small chimneys, dealing with those of a large size is a very serious matter indeed. Their weight is so utterly disproportionate to their strength, even when new, that no machinery yet devised will enable large chimneys to be lowered, either wholly or in part, without very great labor and danger."

As it is well known to every one that it is more difficult to raise a thing than to lower it, the reader will wonder by what extraordinary means these formidable chimneys were ever erected, when it is so very difficult to let them down. The second letter referred to above says: "We have often raised and lowered them, and do not think with such appliances (falls and derricks) that it is either dangerous or a very great labor. We believe \$1,000 or \$1,500 would pay for hinging the chimneys and providing improved appliances by which the largest chimneys in use could be readily lowered and raised." This is the testimony of thirteen experienced steamboat captains, and it is sufficient to refute this second statement of the Board.

The entire weight of that part of the largest chimney which would require to be lowered is only three or four tons. If we assume the length of this part to be 70 feet above the hurricane-deck, and 7 feet in diameter, and made of No. 12 sheet-iron of a strength equal to 50,000 pounds per square inch, a little calculation will show that such a cylinder, if well riveted, will, even after discounting 40 per centum of its strength for the riveted joints, require over three hundred tons to pull it asunder. Standing erect, it will sustain sixty tons with safety. If each end of such a chimney be provided with a strong angle-iron flanch sufficient to preserve its circular form, and it be placed horizontally on rests at its ends, it will support a distributed load over its length equal to half a dozen such chimneys.

The size of chimney named is an extreme one, while the thickness is not unusual, nor is the tensile strength beyond that of good iron. A few of the simplest calculations that are made in the office of an engineer will suffice to disprove completely the third statement of the Board, to the effect that "their weight is so utterly disproportionate to their strength, even when new."

The Board enforces its opinion respecting the necessity of very high pilot-houses by declaring that "experience has decided this point most clearly." This declaration loses all its force when compared with the following simple statement made by the gentlemen just referred to, one of whom is the captain and part owner of the Richmond, which probably carries the highest pilot-house afloat. "In no case is it absolutely necessary for safety (in navigating the largest boats) for the pilot to be more than 35 or 40 feet above the water-line." The fourth statement of the Board is thus shown to be fallacious.

On the assumption that a clear height of 50 feet above directrix is requisite for safe navigation, the report says: "The horizontal chord of the center span, which lies 5 feet below the crown of the arch, is 174 feet long, and gives the least width of waterway which seems compatible with safe navigation." On this assumption it will be evident, presently, that the Board has understated the safe width at least 50 per centum.

The highest part of the boat remaining, when the chimneys are lowered, is the pilot-house. This, on large steamers, is usually surmounted with a pyramidal canopy or roof, the apex of which is of course safe anywhere within the 174 feet. As it is much higher than any other portion of the boat, it follows that when it is at either end of this distance, one-half the width of the steamer must be outside of this 174 feet, and yet in safety under the descending part of the arch, for the apex of this canopy is immediately over the keel of the boat. As the largest steamers are from 85 to 90 feet wide, it is evident that that much more should have been added by the Board to this 174 feet. Therefore, on its own data, this fifth statement, to wit, that the least width compatible with safe navigation is only 174 feet, is also an error. It should have been stated at about 260 feet.

The Board having arbitrarily assumed 174 feet as the only width of water-way compatible with safe navigation afforded by an archway 520 feet wide, and 55 feet high, then endeavors to support the remarkable proposition that if the piers were placed at no greater distance than 174 feet apart, they would be "far preferable" if there were clear headway above. The arguments advanced in support of this novel opinion are equally as notable as the proposition itself. The report says: "The reason given for this is that the piers would define the available width with exactness; they are easily seen and avoided. In the case of a wide arch, however, the case is different. The piers are too far apart to be of service as guides, and lights placed on the structure will be so nearly overhead as to be of no great assistance." Even the possibility of hitting the piers when so close together does not lessen the superiority of the narrow gauge. In this event the board offers the following consolation: "In case of striking the piers under headway, the damage done is to the hull alone; and even if so great as eventually to sink the boat, time will generally be afforded to save the lives of the crew and passengers," whereas in case of a collision with the arch, the Board assumes that the upper works of the boat would be destroyed, and "as the passengers are carried on the upper decks, such an accident would probably be attended with great loss of life." Further on we are told that "the steamboat-men deem a clear height of 75 feet above high water the least admissible," a concurrence in which opinion doubtless actuated the Board in recommending the canal.

In these last few extracts there are three distinct assumptions, and these constitute the 7th, 8th, and 9th errors on which the decision of the Board rests. These are as follows:

1. Lights placed on an arch 50 feet above high-water are of no great assistance.
2. Greater head-room for passing boats is indispensable.
3. Piers 520 feet apart are too wide to serve as guides.

From these three postulates, draw-bridges and narrow piers are absolutely necessary for safe navigation. If lights 50 feet high are "of no great assistance," surely they will be of no use at all 75 feet high; and if piers 520 feet apart are too wide to serve as guides, there would be no means left the bewildered navigator, in approaching an opening 520 by 75 feet, but to run it by the compass, or by buoys placed in the channel.

The absurdity of this corollary proves that the three premises, of which it is a logical sequence, are incorrect.

The fact that all three of these assumptions are errors is fully established by the counter-statements in the letters referred to. In addition to this disproof, the following extract from the report will show the fallacy of two of them, and prove conclusively that the Board itself believed it quite practicable for an arch 55 feet high to be effectively lighted, and its wide piers distinguished with certainty. The report says: "Whether this modification (the canal) be carried out or not, the Board deem it very important that such lights and marks should be displayed by the bridge as will enable boats not only to distinguish the position of the piers and arches with certainty, but also to be able to tell the clear headway available under the bridge."

Reasonable gentlemen would hardly wish to compel the company to display lights to enable boats "to distinguish the position of the piers and arches with certainty," if they really believe "the piers are too far apart to serve as guides, and lights on the structure will be so far overhead as to be of no great assistance." As the latter statement is completely refuted by the former one, I think its insertion in the report must have escaped the notice of the Board. Another proof that the Board was not justified in declaring that the arch is too low, is shown by the following facts, which the bridge company was prevented from laying before the Board. In the spring of 1866, several large meetings were held on 'change in this city by gentlemen interested in protecting the navigation of these rivers. Much discussion ensued as to the proper conditions to be imposed by law in bridging them. A memorial to Congress, presented at one of the meetings, was referred to a committee of the following fifteen gentlemen: J. S. McCune, J. F. Griffith, Barton Able, Joseph Brown, H. C. Moore, David White, J. H. Alexander, William M. McPherson, A. W. Fagin, George Pegram, Adolphus Meior, Felix Coste, James Ward, N. Stevens, and J. B. Eads.

On the 18th of April, 1866, this committee *unanimously* reported a series of resolutions, and from their report I quote the following:

"Your committee have carefully examined the subject with reference to ascertaining what restrictions are really demanded by the marine interest involved, and what can be conceded by those interests to such an extent as to leave no serious difficulties in the way of the requirements of the land transportation in crossing the river, and yet preserve a comparatively uninterrupted navigation on the Mississippi.

"The views of your committee are embodied in the following resolutions, the adoption of which they respectfully recommend:

"*Resolved*, That the delegation in Congress from Missouri be requested to procure at an early day the passage of a law to regulate the construction of bridges over the Mississippi River, and that they earnestly endeavor to incorporate the following provisions in said law:

"1. That all bridges crossing the Mississippi River shall have a clear height of 50 feet over the main channel, between the lower part of the bridge and high-water mark, measured in the center of the greatest span.

"2. If below the mouth of the Missouri, they shall have one span of 600, or two spans of 450 feet each, in the clear of abutments. * * *

"4. No draw-bridge, with a pivot or other form of draw, shall be permitted.

"*Resolved*, That a copy of this report and resolutions be sent to each member of the Senate and House of Representatives from Missouri at Washington."

These resolutions were *unanimously* adopted by the Exchange, and may, therefore, be taken as the authoritative expression of the largest and most influential body of merchants, shippers, and steamboat-men in the valley of the Mississippi. Among the fifteen names are those of ten gentlemen directly interested in river navigation, and, with very few exceptions, these were all representative men in that interest.

In recommending such unusually long spans, the committee was informed at the time by me that arches of such great length were entirely practicable, but that trusses increased in weight so rapidly in proportion to the span, that their great cost made them virtually impracticable. It was for this reason, and with a full knowledge of the fact, that in defining the height, the words "*measured in the center of the span*" were inserted by this committee.

These resolutions were published in the papers at the time, and every one had, therefore, full notice of the height agreed upon, and that that height referred expressly to the center of the greatest span over the channel. After a company has, during the last five years, expended millions of dollars in constructing a bridge with spans greater and higher than those required in these resolutions, and with its plans publicly exposed on 'change all the time, it is a remarkable fact that some of the gentlemen who were most influential in shaping the report of the committee in 1866 have been the most active in 1873 in obtaining from six eminent United States engineers an official declaration that the bridge, whose dimensions they were chiefly instrumental in fixing, will, when completed, prove "a very serious obstruction to navigation;" and this, too, after being prominently active in securing an official declaration from the Merchants' Exchange, of St. Louis, that these dimensions will "preserve a comparatively uninterrupted navigation on the Mississippi." This Exchange is composed of more than 1,000 members, a large number of whom are owners and captains of steamboats, while almost every one in it is more or less directly interested in preserving the navigation of the river. On such questions it can speak more intelligently than any other body in this valley.

It is no justification for the bad faith of these recalcitrant committee-men to say that the Exchange declared in 1873 that 75 feet in height was requisite for the safe navigation of the Mississippi. The Exchange did not, like them, ignore and repudiate in 1873 what it said in 1866. The height of 75 feet, as will be seen by the resolution of last May, applied only to bridges that may be built *below* St. Louis.

It will, on these facts, be conceded that it was an error of the Board to assume that greater height than is given by the center arch of this bridge is really necessary.

The tenth objection to the bridge is because its arches make the following method of navigating bridge-openings impracticable when descending the stream:

"In case of wind, a boat can be dropped through the opening by lines made fast to ring-bolts in the pier itself. The chance of dropping through along the pier is not available in this case, as the arch of the center span springs from a point about at the level of high water of 1844."

* This method of navigating bridge-openings, I think, originated with the Board, as it is not credited to any of the steamboat-men examined, and has not yet, I believe, been used on these rivers. I have never seen a steamboat or other vessel dropped down in a current by a line attached to a ring-bolt below her, and I think the laws of gravity would prevent the success of the system, even if this bridge had unlimited head-room; but as the proposition seems seriously advanced by United States engineer officers of the highest rank, and as objection is made to the bridge, because the proposed system "is not available in this case," I have deemed it proper to question experienced

navigators of the Mississippi on the subject. I quote the following reply from letter No. 2:

"As the face of the piers is only from one-fourth to one-sixth of the length of the large steamers, we don't know how such a thing is possible. Ring-bolts, to be useful in dropping a steamer, must be placed above the boat, not below her. To check the lower end of the boat, as it enters the opening, by fastening to ring-bolts in either pier, would simply result in having the upper end swing around broadside, and would probably wreck her on one of the piers. The upper end could not, of course, be controlled by ring-bolts 150 or 200 feet below. In case of wind it would be still more impracticable."

From this it is evident that, without further explanation, the proposed system of ring-bolt navigation will meet with but little favor from the steamboat-men. On their testimony I feel justified in saying that this tenth statement of the board is not sustained.

The Board thinks the steering through 174 feet of the center of the archway would be a matter of great uncertainty, but the testimony in the letters directly refutes this objection. Letter No. 2 declares on this point: "It would not be a matter of any difficulty. * * * Many of the channels through the difficult bars below St. Louis are not over 100 or 150 feet wide, and these are run by the largest boats, either by buoys in them or by marks ashore." So much for the eleventh objection of the Board.

The report says: "They would moreover state that arched trusses, like those under construction, present so many difficulties to free navigation that, in future, their use should be prohibited in plans for bridges over navigable streams."

It is to be regretted that the Board was not more explicit in defining the "so many difficulties" before condemning the use of a form which often combines the highest economy with the most elegant and graceful proportions in architecture and engineering. Only two of these "many difficulties" are clearly indicated in the report. One is, that it prevents the proposed system of navigation by ring-bolts; and the other is, the danger to life in case the upper works of the boat should come in contact with the arch.

The opinion of practical navigators, as set forth in the letters, seems to prove that ring-bolts would be useless, even if there were no arch to limit the head-room, and therefore the first objection falls to the ground. In the second one, the Board offers only the alternative of narrow piers and danger to the hull *versus* wide arches and danger to the upper works. As practical navigators (see the second letter) assert that injury to the hull would be more dangerous than to the upper works, the second objection falls also. Under this evident diversity of sentiment between practical boatmen and the Board, it would seem advisable not to prohibit the use of arches until experience shall demonstrate what insuperable difficulties will really result here when this bridge is completed. On almost every navigable river in Europe arches are in use, and are passed without delay by steamers. It will be asserted that these steamers are much smaller than ours; but it may be answered that the arches under which they pass are also much smaller and lower. Certainly a large vessel can pass through a large one as safely and easily as a smaller one can through a small archway, if the relative proportions of the arches and vessels be the same.

The report says of the proposed canal: "The steamboat-men have stated to the Board that they would be satisfied with this modification, and the engineers of the bridge company only raise as an objection the delay to trains caused by opening and shutting the draw."

I do not know what authority the Board had for thus committing me to a plan which, in my opinion, is impracticable and useless. No "bridge-engineer" but myself is justified in speaking authoritatively on any proposed modification of this bridge, and I was not addressed on the subject by a single member of the Board, nor in any way notified of its appointment or sitting. Colonel Flad, who was temporarily in charge of the work during my absence, assures me that he gave no authority for any such statement, nor do I know of a "bridge-engineer" who did. If consulted on the subject, I should have objected to the canal, for several reasons: First, it is absolutely unnecessary; second, it would delay the completion of the bridge; third, it would be enormously expensive; fourth, it would destroy all of the wharf of East St. Louis alongside of the canal; fifth, it would ruin the landing for several hundred feet below the canal, by causing a deposit along the shore; sixth, it would involve a draw-bridge, which would be inconvenient and dangerous, if ever opened; and, seventh, it would mutilate the bridge.

It has never been claimed that the bridge will not, to some extent, prove an impediment to the free navigation of the river. A single pier cannot be planted in its channel without involving increased caution on the part of those who navigate it, nor can a structure be thrown across the stream which will not either limit the height of that which floats beneath it, or retard its progress until a draw be opened to let it pass. The right, however, of the traffic which flows east or west to cross the river is fully equal to that of the commerce on the river to go to the north or south. They are both common interests of the whole country, and the one cannot be favored at the expense of

the other without loss to the nation. Both intersect each other at St. Louis in such volume that mutual concessions are imperative to insure the least delay to each other. These facts must be patent to the uneducated mind, and should not be ignored by gentlemen of intelligence when sitting as experts in a matter where the question of what concessions should be made by each of these great interests really underlies the problem they were ordered to investigate. If they had no authority to consider this cardinal question, there was no necessity of convening so much ability; for it requires no great intelligence to discover that two piers standing in the main channel are an obstruction to navigation, and that the sides of an arch are too low to permit the passage of a craft as high as the crown of it. Yet this is really the sum-total of the information given us by the Board. Such a result is no less unfortunate for the Board than for the bridge company. For the ability of its members in their legitimate profession, no one entertains more profound respect than myself. The question of obstruction to navigation, however, is not an engineering one. It is one in which the judgment of experienced boatmen is of more value than that of the ablest engineers living. I cannot help regretting, therefore, that the Board thought its instructions did not require it to hear evidence in favor of, as well as complaints against, the bridge.

Constrained by a sense of official duty not to seek for the testimony of experienced steamboat-men in favor of the bridge, the Board was deprived of the intelligent and liberal opinions of such gentlemen as those whose views are herewith submitted, and the result is that it was unconsciously biased in its judgment while striving to discharge its duty conscientiously. The report, therefore, reflects the absurd objections of the complainants, and some of those are set forth with an amount of superlatives which serve to make their fallacies still more prominent. Unreasonably high chimneys are declared "really essential for an economical combustion of fuel." Dealing with large ones is "a very serious matter, indeed," because their weight is "so utterly disproportionate to their strength," that they cannot be let down "without very great danger and labor;" pilot-houses cannot be lowered because "experience has decided most clearly" that they must be maintained too high for the arch; "great loss of life" will most probably occur if the upper works collide with the arch, but none is expected from the boat striking narrow piers; ring-bolts cannot be used in dropping boats through; "the piers are too far apart to serve as guides;" lights on the arch "will be of no great assistance," and therefore the bridge is not simply declared an *obstruction*, nor even a *serious* obstruction, but "a *very serious* obstruction to navigation."

This recitation of difficulties and objections is greatly to be regretted for reasons beyond those which affect the bridge; for when gentlemen of acknowledged technical ability are led, from any cause whatever, to utter opinions which experience disproves, or judgments which time will reverse, public confidence in the value of scientific acquirements is lessened, whereas their real worth, when legitimately applied, can scarcely be overestimated.

As a remedy for imaginary difficulties, the Board proposes to destroy the stone arches on the Illinois shore, and in their place to make a canal with a draw-bridge over it. One argument in favor of this scheme is as follows: They [the Board] think, moreover, that it will only be in exceptional cases that "boats will desire to pass through this draw, so the delay to trains from this cause will not be excessive." In this opinion I fully concur. I fail, however, to see the propriety of building such an expensive canal for such *exceptional* cases. This one argument alone is certainly sufficient to condemn the proposition it is intended to sustain.

The remarkable decision rendered against your bridge, and the remedial canal proposed, will constitute one of the notable incidents connected with its history. If there be any who still think the structure will prove a very serious obstruction to navigation, the indulgence of a little patience from them must be asked until the completion of the work, and then the bridge will vindicate the judgment of the St. Louis Merchants' Exchange, which officially fixed its dimensions in 1866, and secured from Congress an incorporation of them in the charter of the company, in strict conformity to which the bridge is now being constructed.

Respectfully submitted.

JAMES B. EADS, Chief Engineer.

Letter No. 1.

MAYOR'S OFFICE, ST. LOUIS, November 7, 1873.

To the Illinois and St. Louis Bridge Company, Capt. James B. Eads, Chief Engineer:

DEAR SIR: Having been requested to give my opinion as to whether the Illinois and St. Louis bridge, now building across the Mississippi River at St. Louis, can be considered an obstruction to navigation, I have to state that, in one view of the case: every formidable object placed in the channel of a river is an obstruction to navigation but it is also clear that bridges are a necessity, and that they cannot be built over

large streams without placing piers where they must interfere more or less with navigation.

The spans of the Illinois and St. Louis bridge are the largest arch-spans in the world, the central river piers being over 500 feet apart, and consequently interfere less with the free navigation of the river than any other span-bridge.

From observation and from twenty years' experience as a boatman and navigator of the Mississippi River, if I was in charge of one of our largest steamers, (numbers of which I have commanded,) I would not be afraid to take her through between the piers, even in a storm or any other weather except fog, and it is impracticable to run a steamer anywhere on the river in a fog.

I consider the proposition of the Government engineers, to drop a steamer between the piers *down stream* by the aid of ring-bolts attached to the piers, as entirely unnecessary, impracticable, and contrary to the laws of gravitation.

In relation to the elevation of the spans of the bridge, it would have been better if the arches had been higher, as in some stages of water it may prevent the largest class of steamers from passing under it even if their chimneys were lowered, and to pass under it in high-water would necessitate a change in some portion of the upper works, such as the texas (so called) and pilot-house. I think the pilot-houses could be so located and constructed that the largest steamers could pass under the arches at the highest stages of water, but, in my opinion, it would be at the sacrifice of the symmetry of the boat, and somewhat of the adaptedness of the location and construction of the pilot-house for piloting purposes. As between the present structure without a draw, having piers 500 feet apart, and a structure with a draw and piers only 174 feet apart, I am satisfied the present bridge will obstruct or interfere with a much smaller proportion of the various craft navigating the river.

While I greatly wish that the arches of the bridge, could have been placed higher, yet I know that was impossible from its location and connection with the tunnel, the height of which was arbitrary on account of having to pass under the streets of the city; hence the height of the arches had to conform to the height of the tunnel.

In regard to making a canal around the east abutment of the bridge, on the East St. Louis side, I should think it a poor commentary on the good sense of our lawmakers at Washington to authorize the damming-up of the Mississippi to such an extent as to render it necessary to construct a canal in place of it. Indeed, I think it would be a poor way of remedying the evil, for it would create another, by destroying the East St. Louis levee; and, even if constructed, I do not believe enough steamers would pass through it to pay toll sufficient to maintain it, saying nothing of the original cost.

Finally, the Illinois and St. Louis bridge has now been nearly five years in constant construction, at a cost of probably \$10,000,000, and I consider its completion more vital to the interests of St. Louis than any other public improvement now in progress, and to delay or obstruct its completion would be a very great injury not only to the business of the city, but to the country at large, and especially the commercial development of the West. Whatever inconvenience may be caused the larger class of steamers during extreme high-water, (which is to be regretted,) yet we must come back to the original proposition, viz. Are not the advantages accruing to business and commerce, through the instrumentality of the bridge, of far greater importance than any injury it may entail upon river-navigation? and the answer must be emphatically in favor of the bridge. I consider the time for fault-finding or urging its removal as having more than elapsed, and that now no obstacle should be placed in the way of its earliest completion, leaving the future to dictate what means, if any, may seem necessary to obviate any difficulties that may present themselves; for I consider the structure one of national importance, and in every point of view past modification or removal.

Very respectfully,

JOSEPH BROWN, Mayor.

Letter No. 2.

ST. LOUIS, November 5, 1873.

DEAR SIR: We are in receipt of your letter of November 1, 1873, requesting replies to certain questions herein repeated, which we have answered in their respective order, as follows:

Question. At what height do you deem it really essential to place the pilot above the surface of the water for safe navigation of the largest steamers on this river?

Answer. An elevation that will give the pilot a fair view of the upper outlines of the boat. In no case is it absolutely necessary for safety to exceed 35 or 40 feet above the water-line.

Question. In passing through an archway of this bridge, would it be a matter of very great difficulty to keep the boat within a width of 174 feet, occupying the central portion of the archway?

Answer. It would not be a matter of any difficulty, as the current runs parallel with

the face of the piers. Many of the channels through the difficult bars below St. Louis are not over 100 or 150 feet wide, and these are run by the largest boats, either by buoys in them or by marks on shore. It is when steamers have barges or other vessels in tow that wide spans in bridges are most important. In foggy or very windy weather it would not be safe to attempt running narrow and difficult channels *anywhere* on the river, and in such weather there would, of course, be some danger in passing through the bridge.

Question. Is it a matter of great labor or danger to raise or lower the largest chimneys on the river with the usual appliances of falls and derricks?

Answer. We have often raised and lowered them, and do not think, with such appliances, that it is either dangerous or a very great labor. We believe \$1,000 or \$1,500 would pay for hinging the chimneys and providing improved appliances by which the largest chimneys in use could be readily lowered and raised.

Question. Do you deem such very high chimneys really necessary for economy of fuel or draught?

Answer. We think not; too great a draught may be created for economy; the proper construction of the furnaces render extra lengths of chimneys unnecessary.

Question. If there was clear head-room alongside the piers of the St. Louis Bridge, would it be practicable to drop a large steamer through by means of lines and ring-bolts fastened to the piers, either in windy or clear weather.

Answer. As the face of the piers is only from one-fourth to one-sixth of the length of the large steamers, we don't know how such a thing is possible. Ring-bolts, to be useful in dropping a steamer, must be placed above the boat; not below her. To check the lower end of the boat as it enters the opening, by fastening to ring-bolts in either pier, would simply result in having the upper end swung around broadside, and would probably wreck her on one of the piers; the upper end could not, of course, be controlled by ring-bolts 150 or 200 feet below it. In case of wind it would be still more impracticable.

Question. Do you believe steamboat-men are generally hostile to this bridge?

Answer. We believe, on the contrary, that a large portion are friendly to it, because it proves that wide spans are practicable. Of course they would prefer higher spans, but they recognize the right of the railways to cross the river, and they feel that the steamboat interests must make reasonable concessions. We think the construction of any steamer afloat can be altered at little cost, so as to enable her to pass its arches at all stages of water. These alterations would only relate to her upper works. Large boats need seldom go above the bridge, and can, in high-water, take a little extra care in going through it. If it were located below the city, and in the constant track of the big boats, it would then be important to have the arches much higher.

Question. What do you think of the canal proposed by the United States engineers?

Answer. We think it altogether impracticable.

Question. For safe and convenient navigation, would it be preferable for this bridge to have an opening limited in width by piers to 174 feet, but with clear head-room for chimneys and upper works, or to have an archway of 520 feet, with the central 174 feet of it limited in height to 50 above the city directrix?

Answer. As the portion of the archway that is full 50 feet high is greatly more than 174 feet in ordinary water, and as very high-water comes quite rarely, we think the present form and width greatly preferable, so far as safety is concerned. It is chiefly a question of which is the greatest danger, having the hull collide with the piers or having the upper works damaged by the lower part of the arch. The latter accident would, of course, be much less dangerous, and hence the wide span is much safer.

N. S. GREEN,
Steamer Richmond.

JOHN MCCLOY,
Steamer Continental.

N. BOFINGER,
President St. Louis and New Orleans Packet Company.

JNO. W. CARROLL,
Superintendent St. Louis and New Orleans Packet Company.

HENRY C. HAARSTICK,
Vice-President Mississippi Valley Transportation Company.

THEODORE LAYELLE.

J. P. FITZGERALD.

DANIEL G. TAYLOR.

GEO. W. FORD.

BARTON ABLE.

W. H. BROWN.

J. S. NANSON.

P. YORE.

Capt. JAMES B. EADS,
Chief Engineer of the Illinois and St. Louis Bridge.

B 3.

Affidavit of Mr. John W. Noble.

STATE OF MISSOURI,
County of St. Louis, ss :

John W. Noble, being duly sworn, on his oath deposes and says, that he is acquainted with the proceedings of the Board of engineer officers, so far as the same were made public, under Special Orders No. 169, War Department, Adjutant-General's Office, Washington, August 20, 1873, to examine the St. Louis and Illinois Bridge across the Mississippi at St. Louis, and report whether the bridge will prove a serious obstruction to the navigation of said river; and, if so, in what manner its construction can be modified; which proceedings were had at St. Louis, commencing September 4, 1873; that affiant appeared before said Board with Dr. William Taussig, managing director of the Illinois and St. Louis Bridge Company, affiant acting as attorney and counsel.

That on September 2, 1873, the bridge company had addressed to the said Board of Engineers a written communication, requesting, among other things, that the corporation should be allowed to appear and be represented before the Board by its officers and counsel, to assist in obtaining, arranging, and eliciting testimony, and also requesting the Board to have its proceedings and all testimony adduced reduced to writing by a short-hand reporter. To this communication a reply was received from the Board by the company, in writing, dated September 4, 1873, stating, among other things, that the Board was desirous of having the company represented by its chief engineer, and by any other executive officers of the company, by the company thought best; but the Board did not desire to hear legal counsel, as it was not directed to consider questions of law; and also saying that the Board was not authorized to take sworn testimony, but only such as persons interested might choose to give; and the Board did not therefore consider it worthy of being recorded in the manner proposed. When this answer was received the Board went into open session, and affiant and Dr. Taussig were informed that they might attend if they saw fit. Affiant and Dr. Taussig went before the Board, and there were present also Capt. John S. McCune and some other representatives of the river interest, with Mr. Bryson. Some interchange of opinion was then had between said Taussig, affiant, and the members of the Board, regarding the propriety of the company preparing, arranging, and presenting testimony by affiant, as attorney, on the different branches of facts and statistics as to the navigation of the river, and statistics as to other branches of commerce in connection therewith; the result of which was, that affiant was told that there would be no objection to his presence, but that no legal discussions would be entertained.

The Board then proceeded to hear the statements of Captain McCune and others against the bridge, Colonel Bryson acting as agent or attorney in making suggestions to witnesses against the bridge, propounding questions, and otherwise acting in the capacity of an attorney. Affiant does not mean that the said Bryson was an attorney-at-law, but acted in that character.

The witnesses against the bridge testified concerning the heights of boats, their chimneys; the character of the St. Louis Harbor; the necessity for high pilot-houses and tall chimneys; the comparative safety of raising or lowering steamboat-chimneys; whether they could be lowered and raised at all; whether artificial draught could be used; the expense that would be incurred by preparing chimneys, and the difficulties of piloting boats under the bridge.

The persons who appeared at the different sessions and gave testimony against the bridge were Capt. John S. McCune, Captain Silvers, Capt. E. W. Gould, Capt. J. R. Pegram, Mr. James Collins, and it may be some others. A paper was presented, to the following purport, to the Board: "The river interests, represented by those present, hold that the lowering of the pipes and pilot-houses is impracticable, and any bridge requiring it to be done, for any considerable portion of the season, is a serious obstruction to navigation;" to which were affixed the names of several of the persons opposing the bridge, they being present and assenting thereto. This paper was received by the Board, having been suggested and prepared, as affiant remembers, by General Warren, as a means, it was said, of shortening the investigation.

The bridge company had secured the attendance of a number of steamboat-men entertaining views on the questions which the Board had investigated directly opposed to those already received by the Board, and was prepared to bring forward other river-men of experience, who were of opinion that it was not impracticable to lower steamboat-chimneys and pilot-houses; that it was more desirable to alter the boats than the bridge, and that the alleged difficulties of piloting under the bridge did not exist. Of these the company presented Capt. Bart. Able and Capt. George W. Ford; Captain Ford expressing the opinion that steamboat-chimneys were built a third higher than they ought to be.

Affiant then proposed to meet the paper already received by a paper to the contrary,

signed by river-men holding views exactly opposed to those expressed in the paper received, and asked if it would be received. The president of the Board said he did not think it would.

Affiant then—it being Friday afternoon—proposed an adjournment until next Monday morning, that the company might bring forward its other witnesses, stating that the company had not been informed by reasonable notice of the coming of the Board; that the other side, protesting against the bridge, and upon whose application the special order was issued, had had every means of knowing the questions to be raised and preparing therefor, while the company had had no reasonable notice, and was desirous of the adjournment only to concentrate their testimony. The members of the Board expressed themselves not only as opposed to any adjournment, but to hearing any further testimony, except from the chief engineer, and to make such inquiries of a scientific character as they saw fit.

Dr. Taussig joined with affiant in his request of an adjournment for the purpose of presenting further testimony, stating, in effect, that the other side had had months, while the bridge company had had only a few days; but was also told that there would be no continuance, and that further testimony was not expected except from the engineer and on scientific questions.

Whereupon the bridge company, speaking through affiant and Dr. Taussig, informed the Board that they withdrew from any further participation in these proceedings, leaving Colonel Flad, the engineer, at the request of the Board, to give them such scientific information as they stood in need of.

Affiant has read a printed report, purporting to be a report of said Board, dated September 11, 1873, addressed to the Chief Engineer of the United States Army, wherein appear the following statements: "The apparently unreasonable height and size of the chimneys in general use on these steamboats are really essential to secure a good draught to the furnaces and economical combustion of fuel. Artificial means to procure the same end are generally very expensive, and often ineffective.

"Although it is a comparatively easy task to lower small chimneys, dealing with those of large size is a very serious matter indeed. The elevated position of the pilot-house is necessary to enable the pilot to have unobstructed view of the river ahead and the stern of his boat. Experience has decided this point most clearly."

And wherein it is also said: "There remains still to be considered the practical difficulty of keeping a boat within the limited width necessary for safety. It is the opinion of the Board that this will be a matter of very great uncertainty, and this is also the view taken by intelligent pilots who were questioned on this point;" which report then proceeds to give the reasons stated by said pilots to maintain this proposition.

Affiant says that the said Board did not, and would not, give the bridge company the opportunity to produce before them the testimony they had at command on reasonable notice, and opinions of numerous experienced pilots and steamboat-men, whose views were entitled to consideration, and which would have been against the conclusion and reasons stated in the said report, and above quoted. And further affiant saith not.

JOHN W. NOBLE.

Subscribed and sworn to before me this 26th day of November, A. D. 1873, at my office in St. Louis.

[SEAL.]

THEO. F. CHILDS,
Notary Public, St. Louis County, Missouri.

B 4.

Affidavit of Mr. William Taussig.

STATE OF MISSOURI,
County of St. Louis, ss.:

William Taussig, being duly sworn, on his oath says that he is a member of the Board of Directors of the Illinois and St. Louis Bridge Company, and the chairman of its executive committee; that on the occasion of the investigation had by the Board of engineer officers, convened under Special Orders No. 169, War Department, Adjutant-General's Office, dated Washington, August 20, 1873, to examine the construction of the St. Louis and Illinois Bridge, and report whether the bridge will prove a serious obstruction to river-navigation, and if so, in what manner its construction can be modified—which proceedings were had at St. Louis about September 4 and following days—he was present at the sittings of said Board, and represented the bridge company, in connection with John W. Noble, who acted as counsel for said company.

Affiant states that he has read the affidavit of John W. Noble, dated November 26, 1873, and that the statements therein contained are true; and, in addition thereto, aff-

ant further states that said bridge company has never received from said Board of Engineers or from the War Department any official notification whatever of the issuance of said order No. 169, nor of its object, nor of the grounds of any complaints which may have been made against said bridge, nor of the names of any complainants, nor of the day or time of the sittings of said Board of Engineers, but that said bridge company was entirely ignored and disregarded; that the only information derived by the company of these intended proceedings was from the reports of newspapers some two weeks before the sitting of said Board of Engineers; that the bridge company, being largely interested in the subject-matter to be investigated, and being possessed of, or able to furnish, much valuable testimony and other evidence in relation thereto, expected to be notified and informed as to the character of the complaints made against the bridge; but that, receiving no notice, after waiting within a few days of the meeting, this affiant called personally, on the 30th day of August, 1873, on Colonel Simpson, in order to obtain such information; on which occasion all he could obtain was a printed copy of the order convening said Board, which was handed to him personally, but in no wise took the character of an official notification to the company; that thereupon the president of the bridge company and the undersigned sent to the Board of Engineers a letter, a copy of which is hereto annexed, and received from said Board a reply thereto, a copy of which is also annexed, that at the sittings of the Board of Engineers, to wit, during the whole of Thursday, the 4th, and during Friday, the 5th, of September, up to 2 o'clock p. m. of that day, only the complainants against said bridge and their witnesses were heard and examined by the Board; that during that time a great many persons, witnesses procured by the bridge company to attend, had called and were present for the purpose of being heard, but left again because no opportunity was given them; that on Friday, September 5, at 2 o'clock p. m., the first two witnesses of those in attendance on behalf of the bridge company were given an opportunity to testify, and that at the close of their testimony, it then being late and all their witnesses having left, affiant, in behalf of the bridge company, asked for an adjournment to the next day (Saturday) or to the Monday following, in order to enable the company to bring forward important evidence upon the points involved and as to the complaints made, tending to disprove such statements as had been heard from complainants against the bridge, and which statements were the first intimations the company had of the grounds of complaint. In making this request affiant stated that the bridge company "asked only for as many *hours* as the complainants had had *weeks* within which to prepare their testimony," as was evidenced by the complainants' carefully-prepared plats, schedules, measurements, and otherwise organized opposition to the bridge.

This request was positively denied, and when this affiant stated that a great many old and experienced steamboat-men were ready to disprove the statements of those complaining against the bridge, one of the members of said Board of Engineers, Major Warren, said, "If a thousand steamboat-men should come and say that this bridge was no obstruction, it would not change my opinion."

And thereupon, as affiant further says, the bridge company asked at least for the privilege of being allowed to present a paper signed by steamboat-men and experts similar to the one which had been prepared by the Board of Engineers and by them handed to the complainants present for signature, but of the contrary import. This request was also denied, whereupon the bridge company, represented by affiant and their counsel, formally protested against said proceedings as partial and one-sided, and withdrew from all participation therein.

Affiant says that the bridge company would have been prepared, if sufficient and reasonable time had been granted them, to disprove, by a large number of experienced and expert persons, by statistics, by measurements, and by adducing of facts, all of the grounds of complaint which had been heard and considered by said Board, but by the arbitrary and summary action of said Board they were prevented therefrom.

WM. TAUSSIG.

Subscribed and sworn to before me this 4th day of December, A. D. 1873.

[SEAL.]

THEO. F. CHILDS,

Notary Public, St. Louis County, Missouri.

C.

Personal statement of Colonel James H. Simpson, Corps of Engineers.

ST. LOUIS, Mo., January 17, 1874.

GENERAL: Touching the affidavit of William Taussig, esq., a member of the Board of Directors of the Illinois and St. Louis Bridge Company, and chairman of the executive committee, on the mode of conducting the investigation by the Board of

United States Engineers convened under Special Order No. 169, War Department, Adjutant-General's Office, Washington, August 20, 1873, which is among the papers referred by the Chief of Engineers, United States Army, under date of December 30, 1873, to the Board at its present session, for consideration and report, as senior member of the Board I think proper to make the following answer, so far as it relates to my action previous to the organization of the Board on the 4th of September, 1873:

Dr. Taussig, in his affidavit, swears "that said bridge company has never received from said Board of Engineers or from the War Department any official notification whatsoever of the issuance of said order No. 169, nor of its object, nor of the grounds of any complaints which may have been made against said bridge, nor of the names of any complainants, nor of the day or time of the sittings of said Board of Engineers; but that said bridge company was entirely ignored and disregarded; that the only information derived by the company of these intended proceedings was from the reports of newspapers some two weeks before the sitting of said Board of Engineers."

In reply, I assert that on the 25th day of August, 1873, as senior member of the Board, I addressed the following communication to Capt. John S. McCune, president of the Keokuk Northern Line Packet Company:

"ENGINEER OFFICE, UNITED STATES ARMY,
"1122 Pine Street, St. Louis, Mo., August 25, 1873.

"SIR: In order to facilitate the work of the Board to examine the bridge over the Mississippi River at this city, I would be glad to know the names and dimensions of a number (as great a number as possible) of the largest packets and tow-boats which ply on the river past this city. The information should come from reliable sources, and could be given in a form like the inclosed.

"Very respectfully, your obedient servant,

"J. H. SIMPSON,
"Colonel of Engineers, U. S. A.

"Capt. JOHN S. McCUNE,
"President Keokuk Northern Line Packet Company, St. Louis, Mo."

On the same day that I addressed the above letter to Captain McCune, August 25, I called at the office of the bridge company, on Col. Henry Flad, acting chief engineer of the bridge company in the absence of Mr. J. B. Eads, understood to be abroad, and requested him to furnish such drawings of the bridge as might be necessary for the use of the Board, which was to convene on the 2d of September, for the purpose of determining whether the bridge was an obstruction to navigation. Colonel Flad politely furnished me with an official drawing of the bridge, as may be seen by the following correspondence:

"ENGINEER OFFICE, UNITED STATES ARMY,
"1122 Pine Street, St. Louis, Mo., August 26, 1873.

"COLONEL: I acknowledge, with thanks, the receipt of the tracing, designated 'skeleton' of Illinois and St. Louis Bridge, which you have kindly forwarded to me, in accordance with my request of yesterday. Shall I return it to you, or can the Board of Engineers, which are to convene here on the 2d proximo, have it for file with their report?

"Very respectfully, your obedient servant,

"J. H. SIMPSON,
"Colonel of Engineers, U. S. A.

"Col. HENRY FLAD,
"Chief Assistant Illinois and St. Louis Bridge Company, St. Louis, Mo."

"St. Louis, Mo., August 28, 1873.

"COLONEL: I have the honor to acknowledge the receipt of your favor of the 23d, [26th,] and beg leave to inform you that the skeleton-map of the Illinois and St. Louis Bridge which I sent you need not be returned, but is at your service or that of the Board of Engineers.

"Very respectfully, your obedient servant,

"HENRY FLAD.

"Col. J. H. SIMPSON, U. S. A."

The foregoing will show that the bridge company had at least a week's notice of the meeting of the Board, and of its purpose; and it also answers another portion of Dr. Taussig's affidavit, in showing that the bridge company had not only "as many hours as the complainants had been granted weeks to get their evidence ready," but that each party had the same time.

Dr. Taussig also swears "that the bridge company being largely interested in the subject-matter to be investigated, and being possessed of or able to furnish much valuable

testimony and other evidence in relation thereto, expected to be notified and informed as to the character of the complaints made against the bridge, but that receiving no notice, after waiting until within a few days of the meeting, this affiant called personally on the 30th day of August, 1873, on Colonel Simpson, in order to obtain such information, on which occasion all he could obtain was a printed copy of the order convening said Board, which was handed to him personally, but in no wise took the character of an official notification to the company."

In answer to the foregoing charge, I aver that on the 30th of August I addressed to Dr. Taussig the following letter:

"ENGINEER OFFICE, UNITED STATES ARMY,
"1122 Pine Street, St. Louis, Mo., August 30, 1873.

"SIR: As requested by you verbally to-day, I transmit herewith, for the information of the Board of Directors of the Illinois and St. Louis Bridge Company, a copy of Special Order No. 169, paragraph 10, War Department, Adjutant-General's Office, dated August 20, 1873, directing a Board of Engineers, United States Army, to convene in this city on the 2d proximo, or as soon thereafter as practicable, to examine and report upon the Illinois and St. Louis Bridge.

"Very respectfully,

"J. H. SIMPSON,
"Colonel of Engineers, U. S. A.

"WILLIAM TAUSSIG, Esq., St. Louis, Mo."

This letter certainly bears on its face an *official* character, and with the previous correspondence with Colonel Flad, the acting chief engineer of the bridge company, shows that the bridge company had not only not been "ignored and disregarded," to use the language of Dr. Taussig's affidavit, by the Board, but that as senior member of the Board I had, previous to the meeting of the Board, done everything fairly and in good faith for facilitating the business of the board when it should convene.

But further, Dr. Taussig, while swearing positively that the bridge company had received no *official* notification of the meeting of the Board, in the very next paragraph of his affidavit expressly acknowledges it in the following words:

"That thereupon the president of the bridge company and the undersigned sent to the Board of Engineers a letter, a copy of which is hereto annexed, and received from said Board a reply thereto, a copy of which is also annexed."

The following is an extract from the letter of the president of the bridge company and Dr. Taussig referred to, and will show more fully that the bridge company not only received a copy of the order of the War Department convening the Board, communicated by my letter of August 30, but that they *considered it official*:

"ST. LOUIS, MO., September 2, 1873.

"Col. JAMES H. SIMPSON, Maj. GOUVERNEUR K. WARREN, Maj. GODFREY WEITZEL, Maj. WILLIAM E. MERRILL, and Maj. CHARLES R. SUTER, *Board of Engineers under Special Orders No. 169, War Department, August 20, 1873.*

"The undersigned, the Illinois and St. Louis Bridge Company, having learned from a copy of Special Orders No. 169, issued by the War Department, and obtained from you on Saturday, the 30th ultimo, by personal request, that your honorable Board is convened in this city for the purpose of examining the construction of this company's bridge, and reporting whether it will prove a serious obstruction to the navigation of the Mississippi River, and, if so, in what manner its construction can be modified, begs leave to represent that this company has received no notice and is possessed of no information as to the grounds for or character of the complaint, if any, on which your special order is based, and that, being largely interested in your proceedings and final actions, it feels authorized to respectfully request that you permit it to be represented at your several meetings by counsel."

It is true that the bridge company in the above letter, while admitting the receipt of the order of the War Department convening the Board and acknowledging its official character, also states that it was "possessed of no information as to the grounds for or character of the complaint on which the order from the War Department was based." But they were put in the possession of the basis the War Department had given to the Board for its action, and therefore all I could give the bridge company; and as for the particular grounds of complaint against the bridge, these could not be known until they could be brought out by the Board in its investigations after organizing.

In conclusion, I will state that previously to the assembling of the Board I took all the precaution, as senior and local member of the Board, I could, to obtain from the parties on both sides interested in the bridge question the data proper to be laid before the Board, showing no partiality to either; and that each party had the same and sufficient time to enable them to prepare themselves for the presentation of their

respective cases, in such mode as they deemed best; and this, in my judgment, was all, as an individual member of the Board, before its session, I had any right to do in the premises.

I am, very respectfully, &c.,

J. H. SIMPSON,

Colonel of Engineers, U. S. A., President of Board.

Brig. Gen. A. A. HUMPHREYS,

Chief of Engineers, U. S. A.

D.

Personal statement of Maj. G. K. Warren, Corps of Engineers.

ST. LOUIS, MO., January 16, 1874.

GENERAL: The remark made by me in a meeting of the Board of Engineers on the bridge at this place last September, quoted by Mr. William Taussig in his affidavit sent to the honorable Secretary of War as showing a want of fairness toward the bridge company, was made, as those present know, at a time when all the information necessary to decide the matter under consideration was before the Board. The motive in making it was to assure Mr. Taussig that, as far as I was concerned, his case lost nothing by not hearing the steamboat-men whom he had proposed to bring the following Tuesday. It was then Friday, and the Board, owing to other pressing public duties, were unable to adjourn until the time thus asked for.

We had, at the time, the drawings of the bridge, furnished by the bridge company, and we had verified by measurement the principal dimensions shown on the drawing. We had also the dimensions by measurement of the steamboats of the class whose business required them to pass the bridge. There were the steamboats themselves, and there was the bridge itself before us. From these alone it was plain to see with our eyes that a majority of these boats could not pass the bridge at all, which was proof the bridge was a serious obstruction. It was an undeniable fact. But, in addition to this, many of the principal business men engaged in the navigation of the river at the present time had stated to us that the bridge was a *most serious obstruction*, which would, when completed, to use their own words, "practically cut the river in two." In the face of this positive statement of those injured that they are injured, I did not give much weight to the statement of those who are not injured on account of not being engaged in river-navigation. It is sufficient to make a thing a nuisance that it be obnoxious to a large portion of the public by interfering with their rights. This is especially true as to the effect of this bridge on navigation, for it injures all those wishing to pass it, and is only harmless to those who have no large boats engaged in business requiring them to pass it. The steamboat-men (so-called) whom Mr. Taussig presented to us are not now engaged in river-navigation, and I have no doubt that a close examination will show that all steamboat-men who may be got to say the bridge is no obstruction have no occasion to pass the bridge, or are in some way benefited by the injury received by others. It is, therefore, beyond doubt that, according to the statements of men truly representing the steamboat interest, the bridge is a serious injury to navigation.

I wish to state that I have been since the autumn of 1866 (under a resolution of Congress) engaged at various times in collecting information on the subject of building bridges across the Mississippi, between St. Paul and St. Louis, so as to cause the least obstruction to navigation. I have in this period also been a member of many boards of engineers considering bridges at different places, and on one such board the question of bridging for the whole Ohio River was considered. I also planned the bridge across the Mississippi at Rock Island, and located the abutments and piers. I have also been a member of several engineer boards on various river-improvements and in charge of improvements. I have had steamboats and steamboat-men directly under my control. In all these operations I have been in frequent consultation with steamboat-men, and believe I know their views generally on the subject of bridges nearly everywhere on the western rivers. Therefore, in considering the bridge here in the heart of the Mississippi Valley, which threatens to sever or clog this great artery of commerce in its middle course, I feel that the opinions of river-men in any one locality should not be allowed to materially affect my judgment.

Besides this personal experience, I had read the voluminous proceedings in the Wheeling-Bridge case, which in essential features was like the one at St. Louis, where all the points raised at St. Louis about high chimneys and high pilot-houses were fully considered and discussed, which bridge the Supreme Court required to be removed, although there were then but nine steamboats interfered with by it. I had

heard all this matter talked over at Cincinnati about a bridge that Congress has since required to be raised, so that I really believe I know all that could be said on the questions involved. Thus I said to Mr. Taussig, as quoted by him, (in order to show him that higher considerations than the statement of irresponsible river-men controlled my mind,) "That if a thousand steamboat-men were to come and say the bridge was no obstruction it would not alter my opinion." I meant no disrespect to the steamboat-men. I believe there are none of them now engaged in river-business that will say it is no obstruction to navigation. I do not believe there is *any* disinterested man who will come and look at the bridge, who will say it is no obstruction. Those who may doubt the correctness of my opinion, and the report of this Board, should come here and look at the bridge and at the steamboats, and not make up their minds by such misleading illustrations as have been lately given out from the press of the "Democrat" of this place. There can be no doubt that this bridge is an obstruction to navigation. What modification of the bridge will remedy this is one of exceeding difficulty. If it should prove that no change that can be devised and carried out will satisfy the interests of navigation, without destroying the usefulness of the bridge, then justice demands the bridge must come down and a suitable one take its place.

I am not indifferent to the importance to the public and to this great city of having a reliable means of crossing the river at all times. I am not indifferent to the interest of those who have lavished their money in this undertaking; but a greater public interest should not be destroyed unnecessarily for their sake. I am convinced that a bridge suited to this great want, at an expense much less than has already been made, almost if not entirely unobstructing navigation, could years ago have been completed, upon designs well known and tried in this country, had not the authors of the present monster stood in the way.

G. K. WARREN,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Correspondence between the Board of Engineers and Mr. J. B. Eads.

E.

ENGINEER OFFICE, UNITED STATES ARMY,
1122 Pine Street, St. Louis, Mo., January 14, 1874.

SIR: The Board of United States Engineers on the St. Louis bridge have re-assembled to prepare estimates of the cost of making the cut and draw-bridge which they recommended around the east abutment of the bridge. Your reply to the report of the Board is among the documents which have been referred to them.

As you were absent when the Board held its first session, and may be desirous to present your views in person, they take this opportunity to notify you that they are prepared to give you a hearing. As their time is limited, they would suggest that you call at 1122 Pine street at such hour to-morrow morning after 10 o'clock as may be convenient to you. Captain McCune has also been invited to call to-morrow.

Very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers, U. S. A., President of the Board.

J. B. EADS, Esq.,
Chief Engineer Illinois and St. Louis Bridge Company, St. Louis, Mo.

A true copy:

J. H. SIMPSON,
Colonel of Engineers.

F.

ILLINOIS AND ST. LOUIS BRIDGE COMPANY,
CHIEF ENGINEER'S OFFICE,
Nos. 213 and 215 Washington Avenue, St. Louis, January 15, 1874.

SIR: I have the honor to acknowledge receipt of your letter of 14th instant, notifying me of the re-assembling of your Board "to prepare estimates of the cost of making the

cut and draw-bridge which they recommended around the east abutment of the bridge, and stating that my "reply to the report of the Board is among the documents which have been referred to them."

Your offer to give me a hearing at any time to-day after 10 o'clock, if I desire it, is likewise noted in your letter, and also the fact that Captain McCune has been invited to be present.

Having nothing to communicate on the subject beyond what is embraced in my review of the report of the Board, a copy of which you possess, and thanking you for the courtesy of your notification and invitation to be heard by the Board,

I have the honor to be your obedient servant,

JAS. B. EADS,
Chief Engineer.

Gen. J. H. SIMPSON,
President of Board, &c., United States Engineers.

Q 4.

PONTON RAILWAY-BRIDGE ACROSS THE MISSISSIPPI AT PRAIRIE DU CHIEN.

Report of Colonel J. N. Macomb, Corps of Engineers.

ROCK ISLAND, ILLS., May 6, 1874.

GENERAL: I have the honor to acknowledge the receipt of your letter of 14th ultimo, transmitting to me for report a letter of 9th April, 1874, addressed to the Hon. Secretary of War by the chairman of the Committee on Commerce of the Senate of the United States, inclosing H. R. bill 2538—

To legalize and establish a ponton railway-bridge across the Mississippi River at Prairie du Chien—

and requesting information and suggestion in regard to proposed laws.

On the receipt of your letter I gave instructions to my assistant engineer, Mr. E. F. Hoffman, to proceed to Prairie du Chien and make the requisite examination on which to base the report called for; and I now beg leave to present his report upon the subject, by which it appears that while the bridge in question is exceptionally free from objection, as an obstruction to the navigation, it only conforms to existing laws regulating the bridging of the Mississippi River, in that it affords excellent facilities for steamers and rafts to pass through the draw-openings. In view of this fact, it is suggested that in legalizing the construction of the bridge it should be required that the draw-openings be maintained without any reduction of their existing widths.

The third section of the proposed act seems to provide amply for all alterations in this bridge that may be found necessary hereafter for the better protection of the navigation.

The papers sent to me for report are herewith returned as required.

I remain, very respectfully, your most obedient servant,

J. N. MACOMB,
Colonel of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Report of Mr. E. F. Hoffman, Assistant Engineer.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., May 6, 1874.

COLONEL: In obedience to your order, contained in the letter of the 23d ultimo, I proceeded to Prairie du Chien, Wis., for the purpose of examining the crossings of both channels of the Mississippi River at that place. I report as to the extent to which this bridge at Prairie du Chien will obstruct the navigation of the river, as follows:

The river between Prairie du Chien, Wis., and North McGregor, Iowa, is divided into two branches by an island. The eastern channel, Prairie du Chien side, is solely used by the large steamers of the different packet companies; the western channel, North McGregor side, is exclusively the water-way which is chosen by rafts of any size. The towns of Prairie du Chien and North McGregor are connected by a bridge. The bridge is constructed of piles driven into the bed of the river, over which rests a single railroad-track. Length of the bridge, measured upon the track, 7,200 feet from one shore to the other. There are two ponton-draws in this bridge. The draw inserted into the pile-bridge of the eastern channel consists of three pontons connected lengthwise firmly, and representing a distance of 396 feet. Two pontons have each one 28 feet beam—the middle one 17 feet. The draw, inserted into the pile-bridge of the western channel, consists of but one ponton, having a length of 408 feet by 28 feet beam. The pontons have a height in their sides of 5 feet and $4\frac{1}{4}$ feet, and a draught of 10 inches and 12 inches. When trains are passing over the draught increases to 16 and 18 inches. The varying height of the planes between the pile-bridge and the pontons is overcome by aprons or inclined planes. The draws are opened by the current of the river in less than one minute, as soon as the connection of the ponton-draw with the pile-bridge is broken. The closing of each draw is effected by a small engine which pulls the end of the draw, by means of a chain, into its connection with the bridge again. This operation requires from 3 to 4 minutes. In reference to navigating the draws, I state that both are located in good, deep water, but the direction of the current strikes the eastern draw at an angle of $75^{\circ} 30'$, and the western channel at an angle of 55° . It will be therefore seen that the benefit of the length of the 396 feet in the eastern draw and the length of 408 feet in the western draw practically is reduced to 383 feet and 334 feet, viz, $396 \text{ feet, sin } 75^{\circ} 30' = 383 \text{ feet}$ and $408 \text{ sin } 55^{\circ} = 334 \text{ feet}$. The bill pending in Congress in relation to this bridge demands not less than 250 feet for the eastern draw, and not less than 320 for the western draw. It will be therefore seen that the builders of the bridge and draw have not only complied with the requirement but even increased the lengths of each of the draws, and that the bridge as constructed seems to be in accordance with the requirements of the act approved 4th of June, 1872, "further regulating the construction of bridges across the Mississippi River," as far as concerns the ready passing of boats and rafts through said bridge. At the same time it should be remarked that the draw-openings alone afford the way of passing through, and that such a bridge as the above-described combination of pile-work and pontons can only be authorized across the Mississippi River by the enactment of a special law as proposed, and the act should be entitled an act to legalize and establish a pile-bridge with ponton-draws upon which to locate a railway across the Mississippi River; and in view of the fact that the draw-openings at each channel are single, the width which said draws respectively have, as described in this report, shall not be diminished. In relation to the navigation, I have to state that the captains and pilots unanimously opine this bridge to be the easiest to pass on the whole river, and consider it not to be obstructive to navigation. The accompanying sketch shows approximately the location of the bridge.

I have the honor to be, colonel, your most obedient servant,

E. F. HOFFMANN,
Assistant Engineer.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

APPENDIX R.

ANNUAL REPORT OF CAPTAIN C. W. HOWELL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1874.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., October 5, 1874.

GENERAL: I have the honor to submit the following reports of progress made in all works of river and harbor improvement under my charge, for the fiscal year ending June 30, 1874.

Very respectfully, your obedient servant,

C. W. HOWELL,
Captain of Engineers. U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

R 1.

IMPROVEMENT OF THE MOUTH OF THE MISSISSIPPI RIVER.

This work was continued throughout the fiscal year at Pass à l'Ouvre.

DREDGING AND RESULTS.

A tabular statement is appended hereto giving detailed information regarding dredging, its results, and the conditions of winds, tides, currents, and stage of river attending it; also commercial statistics regarding the use of the channel made.

The following is a brief synopsis.

Tabular statement of dredging and results.

Month.	Number of hours dredging on bar.	River— Rising..... (+) Falling..... (-) Nearly at a stand. (0)	Number of days the channel had a depth at extreme low tide as indicated below.								Tides ranging above extreme low water, in feet.	Number of vessels using the channel.	Greatest draught of vessels in feet.	Number of vessels detained.	Feet.												Loss.	Knob.		
			Feet.																											
			174.	177.	164.	166.	154.	155.	144.																					
			174.	177.	164.	166.	154.	155.	144.																					
July.....	118.05	(-)	6	2	8	15	0	0	0	1 3-12 to 2	59	19	5	20	134	17.	174.	18.	184.	19.	20.	15.	16.	17.	18.	19.	20.	26	1	
August.....	89.45	(-)	0	16	0	14	0	1	0	1 to 2 6-12	35	18 6-12	3	1	134	13		71		28								26	1	
September.....	18.00	(0)	0	0	0	30	0	0	0	1 to 2 3-10	40	15	3	12														14	1	
October.....	31.10	(0)	0	0	0	7	0	94	0	2 5-10 to 2 6-12	31	15	3	5														12	1	
November.....	6.10	(0)	0	0	0	0	0	0	30	2 6-12	59	15 6-12	3	15														5	12	
December.....	68.35	(+)	0	0	0	0	0	0	30	2 6-12	31	16	3	16														50	12	
January.....	172.45	(+ and -)	0	0	92	9	0	0	7	1 to 2 6-12	74	19	6	19			4	184	1	146								4	19	
February.....	118.35	(0)	0	0	25	3	0	0	0	2 to 2 6-12	30	18 4-12	10	20			328		130									4	10	
March.....	25.30	(+)	0	0	0	45	2	0	4	to 2 6-12	100	18 10-12	12	30			696		3584									96	10	
April.....	41.35	(+ and -)	0	0	0	0	6	13	5	1 to 3	35	10	13	10					35									12	36	
May.....	189.10	(-)	0	0	0	0	7	10	0	to 3	62	18 8-12	4	10					11									17	5	
June.....	182.35	(-)	0	11	7	10	0	3	0	3	62	18 8-12	4	10														34	94	
Total.....	1,061.55	(-)	6	39	87	96	31	96	30		596	53	146	39	5914	6	2464	7114	1384	220	10	178	25	1	1	1	1	1	1	1

SOUTHWEST PASS.

Southwest Pass during the year retained its normal depth, and was much used for light-draught vessels.

Attempts in February and March to pass deep-draught vessels resulted in the usual blockade, which was maintained until a considerable fleet had been collected inside and outside the bar.

As, during this time, Pass à Loutre afforded a good channel, the parties controlling the fleet were finally forced to transfer it to Pass à Loutre, where it passed the bar with but little trouble, as it might have done a month previous.

Leaving Southwest Pass in its normal condition and improving Pass à Loutre permits a course of action that will greatly aid in preventing blockades, viz, the sending of all vessels not drawing more than 16 feet to the former, and all deeper draught to the latter.

In this way a rush of vessels at particular seasons will be avoided at either pass, and greater care can be observed in selecting times and tides for crossing.

For the past few months this course has been partially followed, the local interests at Southwest Pass drawing to that place nearly all vessels of the lighter draughts, while the representatives, in New Orleans, of the commercial interests have insisted on having their deep-draught vessels taken to Pass à Loutre.

The result has been very satisfactory.

THE DREDGES.

Both dredge-boats were repaired during the year, and at its close both were in good working order and employed on the bar.

The McAlester will need but slight repair this fall to put her in condition to work throughout the year.

The Essayons will need greater repairs, and next year must be thoroughly overhauled.

The end-dock, steam-launch, and barge are in good order.

SURVEYS.

Surveys were continued as heretofore, but the field of survey greatly extended so as to cover the bars at Pass à Loutre, South Pass, and Southwest Pass several miles seaward of their crests, and the heads of the passes.

COMMERCIAL STATISTICS.

The following commercial statistics have been received from the office of the collector of the port of New Orleans :

	1870-'71.	1871-'72.	1872-'73.	1873-'74.
Number of entrances, steam-vessels	916	616	385	467
Tonnage	949, 230. 06	639, 943. 88	404, 437	452, 265
Number of clearances, steam-vessels	1, 201	704	444	477
Tonnage	1, 231, 161. 15	739, 850. 21	473, 965	465, 469
Number of entrances, sailing-vessels	1, 091	945	838	846
Tonnage	562, 624. 46	436, 650. 77	457, 896	472, 533
Number of clearances, sailing-vessels	1, 141	1, 000	811	843
Tonnage	566, 415. 69	457, 996. 23	517, 833	453, 056
Total value of imports, specie, free and dutiable	\$19, 331, 119 00	\$18, 542, 188 00	\$19, 933, 180 00	\$14, 714, 326
Total value of exports, domestic, to foreign countries	\$93, 953, 081 00	\$89, 501, 149 00	\$104, 329, 965 00	\$96, 798, 336
Total value of exports, foreign, to foreign countries	\$1, 293, 710 00	\$1, 301, 700 00	\$285, 127 00	\$297, 023 00
Grand total of exports	\$95, 246, 791 00	\$90, 802, 849 00	\$104, 615, 092 00	\$97, 095, 359 00
Amount of revenue collected on imports	\$5, 699, 390 85	\$5, 184, 053 93	\$3, 732, 550 78	\$2, 398, 428 34

PROJECT FOR THE YEAR ENDING JUNE 30, 1875.

The work will be continued as heretofore.

Both dredges will be kept at Pass à Loutre during the summer with but one crew.

In October the McAlester will be repaired and put on duty at the bar. The Essayons will then be brought up, repaired, and retained in port until the river rises. Afterward, both dredges will be kept at the bar.

Should it prove advisable, one boat will be sent occasionally to Southwest Pass to keep the channel there in fair condition for the passage of light-draught vessels.

The work is not susceptible of permanent completion.

It is located in the collection-district of New Orleans and near the light-house at Pass à Loutre.

GENERAL REMARKS.

The recent legislation giving the Secretary of War authority to establish and enforce certain regulations governing the use of the pass improved, although regulations have not yet been drawn, has already had a beneficial effect. The facts on which it was based were not generally known, and the monopoly at which it struck was in a position to overawe its victims. This is now changed. The monopoly has been broken down, and in its place we have a very promising opposition in the tow-age business.

Pilots, ship-masters, and ship-agents are resuming their proper authority, and, understanding the necessity for a system of laws, to govern their action, that looks to the general good rather than the aggrandizement of a corporation, are acting now very much as they should. For example—many pilots are taking greater pains to familiarize themselves with the channel; masters frequently wait for a high tide when their vessels are deeply laden; agents of steamers, when it is necessary, take tow-boats to insure crossing the bar without detention, and the tow-boat companies are willing to render such assistance without waiting for the vessel to get hard aground.

These are but a few indications of a growing, healthy, commercial sentiment, which, properly fostered, will make dredging as beneficial to commerce as it may be made, and place the efforts of the Government at their proper value.

The depths of channel given in this report, it should be observed, have been obtained by reducing the actual soundings to the plane of extreme low-tide for the year. This departure from the usual rule, adopted in hydrographic work of reducing to mean low-tide, was made for the purpose of inducing greater care on the part of persons using the channel, and has, I think, been of practical benefit.

I have not worked up my records from self-registering gauges so as to ascertain how far the plane of mean low-tide is above that of extreme low, but an inspection of the records indicates that the difference is between 8 and 10 inches.

Great care has been taken in making the soundings, men being employed who have, by constant practice, become expert and give the surface even where the bottom is softest.

Mushroom leads have been used, and their length not included in the measurement of the sounding-line—this length is about four inches. The lines were the best close-laid attainable in this market. These have been wetted, thoroughly shrunk and measured each time before using,

and after using remeasured. The depth reported is the least depth obtained by cross, diagonal, and longitudinal soundings, between buoys located by triangulation; in many cases but one, two, or three soundings for this least depth have been obtained from the whole number, of from 600 to 800 soundings made in the channel. The width of channel reported is also the least width.

This statement goes some way toward explaining why vessels drawing from 2 to 4 feet more water than reported in the channel have passed the bar without detention.

Adding to the depth reported, the height of tides as shown by the preceding table, and one foot for semifluid mud, gives the actual commercial value of the channel.

For example, in February, the depth reported was from 16 to 16½ feet + tide 2 feet = 18 to 18½ + 1 foot mud = 19 to 19½ feet. During this month a 20-foot vessel was delayed 146 hours, one drawing less than 15 feet 10 hours. No other vessels were delayed.

The 20-foot vessel (a steamship) delayed had a jury rigging for her rudder, and grounded because unable to steer properly.

A sailing-vessel drawing 19 feet 7 inches, with the same depth of channel, (16½ feet,) passed out a few days ago with but two hours' detention.

With the dredges now employed, and the manner of obtaining and reporting depth and width of channel, my reports do not show the maintenance, throughout any one year, of a channel 18 feet deep and 300 feet wide. Depths of from 17 to 20 feet at extreme low tide are frequently reported, but never a width of 300 feet for those depths.

Yet it was reported that in 1859 and 1860, for a whole year, a depth of 18 feet and a width of 300 feet was maintained by simply dragging harrows and scrapers over the bar at Southwest Pass, and at a cost of only \$60,000. Also, that under the contract of Craig & Rightor the same depth and width was obtained at Southwest Pass and Pass à Loutre, the latter by exploding a few hundred pounds of gunpowder on the bar.

My experience on this work during 1869, 1870, and 1871 convinced me that there was something wrong about the measurements on which these reports were based. If not, then we were spending \$150,000 a year with a plant worth \$500,000, when as good results might be obtained for \$60,000 a year.

I investigated the matter. I questioned pilots, tow-boat captains, ship-masters, and employés of the contractors who received pay for the results reported. The information so obtained could not be put in shape for report, for the reason that while the men interviewed would freely tell me what they knew they were unwilling to sign written statements. A few months ago a suit for libel was brought against me by the Tow-boat Association, which offered an opportunity to bring this testimony out; but the suit was withdrawn and costs paid by the plaintiff.

In view of the fact that I have satisfied myself that the depths and widths of channel reported in 1853, 1857, 1858, 1859, and 1860 have been erroneously reported, it seems proper to state my grounds for belief.

There are many tricks about sounding that, while generally known to sea-faring men, are unknown to or escape the observation of the most conscientious and careful inspectors. I will explain some of them.

There are various qualities of lead-lines; all shrink more or less on being wetted.

Experiments I had made with several qualities found in this market resulted in showing a shrinkage of from 6 inches to 2 feet in a length of 20 feet. An inspector who does not select his lines and measure them

himself when thoroughly wetted, neglects a prime precaution against getting wrong results.

There are various shapes and sizes of leads suited to different kinds of soundings.

Where the water is only about 20 feet deep and the bottom soft, as at the mouth of the Mississippi, accurate results can only be obtained with a light, flat lead, since a long lead, and especially a heavy one, though well thrown, will sink a great part of its length into the bottom, and, whether the lead-line be measured from the lower or upper end of the lead, wrong results are obtained. Then much depends on the honesty of the leadsman. Even when the water is smooth, it requires an experienced and close observer to determine if he be not calling from 6 to 12 inches more or less than the actual sounding. In rough water it is yet more difficult to detect error of this kind, since the leadsman himself must average the rise and fall of the waves to give the true sounding.

It will be seen from this how, even ascribing to contractors and leadsmen average honesty, and to inspectors average knowledge of and attention to what has been stated above, erroneous results may be obtained.

Returning to the works of 1853, 1857, 1858, 1859, and 1860, all my informants agree that those works at no time afforded a channel more than 16 feet in depth at mean low-tide. Why was a greater depth reported?

The contractors provided the leadsman leads and lead-lines; the leads were long and heavy, such as used for off-shore soundings; the lines were measured dry, and from the lower end of the lead; the soundings were often taken from the bow of a steamer, with the inspector in the pilot-house, watching the leadsman as well as he could, recording the calls, and his attention distracted as much as possible by the conversation of persons about him.

In one case they were taken from boats, one on either side of the steamer, at a distance of 150 feet from the latter, with the inspector on the steamer.

These soundings, it was thought, were verified by triangulation, the inspector and his assistant using the instruments from stations on mud-lumps distant from the channel, while soundings located were made from small boats by the contractor's employes.

My informants were, some of them, at the time cognizant of the fact that the inspectors were being systematically deceived, as I have indicated.

I give the statement of a master of a dredge-boat, as near as I can remember it, as a sample of my information:

We had a channel between 15 and 16 feet deep; the contractors reported it 18 feet deep and called for inspection. I was notified that the inspector would be down on a certain day.

I selected the most loosely-laid lead-line I had and stretched it over the boiler of the boat, fastening it at one end and attaching a weight at the other.

When the inspector came aboard, the line was thoroughly dry and stretched. Our other lines were put out of sight. The inspector took our prepared line, carefully measured and marked it himself. We then ran down to the bar. As we neared the bar the leadsman was instructed to take soundings in water that we knew was over 18 feet deep, ostensibly to show the depth above the bar, but really to wet the line so that it would be properly shrunk before using on the bar.

We then sounded back and forth through the channel, the inspector standing by the leadsman and watching every throw, as if he thought he could judge from mere sight whether the leadsman was throwing and calling honestly or not. There resulted the reporting of a channel over 18 feet deep at mean low-tide, when there was really not a channel 16 feet deep.

The result not only deceived the inspector, but exceeded my expectations, as I had taken pains to impress on the inspector the fact that shoaling in the channel was rap-

idly effected, and that a little less than 18 feet might possibly be found for one or two soundings. This was the subject of remark after completing the inspection, but the inspector did not think of again measuring the lead-line, nor would such a course have enlightened him, for as soon as the soundings were completed I had it put out of sight and another line exactly like it and properly measured substituted for it.

This is the substance of what one witness stated to me in conversation.

This *exposé* appears necessary to put the work of to-day in its proper light when comparison between it and past works is attempted.

It may also suggest to future inspectors some points of value.

Financial statement.

Balance in the Treasury of the United States July 1, 1873.....	\$35 083 00
Amount in hands of officer and subject to his check.....	7,748 55
Amount appropriated by act approved April 3, 1874.....	30,000 00
Amount appropriated by act approved June 23, 1874.....	130,000 00
Amount expended during the fiscal year ending June 30, 1874.....	117,503 40
Amount available July 1, 1874	135,328 15
Amount required for the fiscal year ending June 30, 1876, running expenses \$150,000, repair of dredge \$100,000.....	250,000 00
Total amount appropriated since June, 1869.....	934,823 53
Total expended since June, 1869.....	849,555 32

ANNUAL REPORT OF THE CHIEF OF ENGINEERS ON THE IMPROVEMENT OF THE MOUTH OF THE MISSISSIPPI RIVER.

Date.	Wind at Pass & Loure.				Stage of river at New Orleans—12 m. below high water of 1872. Gauge at foot of Canal street.	Hours worked by dredge boat.	Depth of channel at extreme low-tide.	Height of high tide above extreme low-tide.	Total depth of channel at high-tide.	Least width at extreme low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties.				Remarks.
	6 a. m.		12 m.										Number of vessels aground.	Greatest draught.	Time of delay.	Locality.	
	Direction.	Force.	Direction.	Force.													
1873. July																	
1					3.9												
2					4.1												
3	S.	3	S.	3	3.9												
4	S.E.	1	S.E.	1	4.1	11 0	17½			180	1	1					
5	0	0	0	0	3.7	10 45					1	1					
6	W.	3	W.N.W.	2	4.3	6 45				180							
7	S.	1	N.N.W.	1	4.3	10 45	17½				1	1					
	N.N.E.	1	0	0		10 30											Steamer George Washington, bound out, and steamer Cortes, bound in, grounded north of channel. These vessels came from Southwest Pass, where they were unable to cross.
8	S.W.	1	0	0	4.0	9 45				150		1					Coaling Essayons & repairing boiler.
9	S.	1	E.	1	4.3	6 55	16	2	18	150	2	1					Do.
10	N.N.E.	3	N.N.E.	2	5.1		16	2	18	150		1					Steamer General Meade, bound out, grounded north of channel.
11	N.W.	2	N.	1	5.3						1	2	1	16 6	13½		General Meade got off bar, assisted by Essayons; steamer Minnesota, bound out, grounded at upper end of channel.
12	W.	2	N.W.	3	5.4	6 40	16½			150	1	4	1	19 0	28		Essayons collided with Minnesota, while assisting her over the bar, damaging deflector of dredge, necessitating trip to city for repairs. Minnesota sailed.
13	W.	1	N.	1	5.1	7 30	16½	1½	18	150							Essayons arrived at New Orleans and commenced repairs. Repairing deflector and machinery of Essayons.
14	E.	3	N.E.	3	5.4							3					Do.
15	E.	4	E.	3	5.7						1						
16	E.S.E.	3	E.S.E.	3	6.0							2	3				
17	E.S.E.	3	S.E.	3	5.7		16	1½	17½	100	1						

To star statement to ac company annual report for the year ending June 30, 1874, &c.—Continued.

Date.	Wind at Pass & Loutre.				Hours worked by dredge-boat.	Depth of channel at extreme low-tide.	Height of high-tide above extreme low-tide.	Total depth of channel at high-tide.	Least width at extreme low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties.				Remarks.	
	6 a. m.		12 m.									Number of vessels	Greatest draught.	Time of delay.	Locality.		
	Direction.	Force.	Direction.	Force.													
1873. July 18	Stage of river at New Orleans—12 m. below high water of 1872. Gauge at foot of Canal street.	Feet.	W.	1	E.	1	16	14	17½	100	1	1				Repairing deflector and machinery of Easyons.	
19		5.9	S.W.	2	E.	3	16	14	17½	100	1	2				Do.	
20		5.3	W.	1	E.	1	16	14	17½	100	1	3				Do.	
21		5.0	E.	1	E.	1	16	14	17½	100	1	3				Do.	
22		5.5	S.E.	3	S.W.	2	16½	2	18	86	2	2				Do.	
23		5.2	S.W.	2	S.	3	16½	2	18	86	2	2				Do.	
24		5.5	E.	2	E.	1	16	2	18	86	2	2				Do.	
25		5.3	W.	3	E.	2	16	2	18	86	2	2				Do.	
26		5.9	N.	2	N.N.E.	2	16	2	18	80	1	1				Finished repairs. Easyons started for Pass & Loutre.	
27		5.7	0	0	N.E.	2	16	2	18	80	1	3					
28		5.9	S.	1	0	0	16	14	17½	100	1	1	1	11	6	20	Slight accident to machinery delayed work.
29		6.1	W.	1	N.N.W.	1					1						Schooner Lily of the Valley, bound out, grounded north of north line of buoy.
30		6.7	S.	1	0	0	16	14	17½	100	1	1					Schooner Lily of the Valley, sailed, assisted by Easyons.
31		7.2	S.	3	S.	2	8 0				1						Work delayed on account of slack current.
August 1		7.5	E.S.E.	1	S.	2	16	1	17	100	1						Do.
2		8.1	W.	1	W.	2	17		80		1						Do.
3		8.5	N.N.W.	3	S.S.W.	2	7 0				1	1	1	18	6	71	Easyons struck some hard substance and broke blade No. 3.
4		8.9	W.S.W.	1	S.	1	6 10										Steamer Caledonian, bound out, grounded north side of channel.
5		9.2	W.	2	E.	2	17	14	80		2						Dredge pulling on Caledonian.
6		9.5	W.	3	S.W.	1	17	14	80	1	2						Dredge pulling on Caledonian; Caledonian got off bar. Easyons started for New Orleans to repair steamer.
7		9.9	E.	3	E.	2	17	2	19	90	2	1					Easyons at New Orleans.

[illegible]

Tabular statement to accompany annual report for the year ending June 30, 1874, &c.—Continued.

Date.	Wind at Pass à Louvre.				Hours worked by dredge-boat.	Depth of channel at extreme low-tide.	Height of high-tide above extreme low-tide.	Total depth of channel at high-tide.	Least width at extreme low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties.				Remarks.
	6 a. m.		12 m.									Number of vessels aground.	Greatest draught.	Time of day.	Locality.	
	Direction.	Force.	Direction.	Force.												
1873.	Feet.	E.	N. W.	16	2 3	18 3	50									
Sept. 23	13.2	0	N.	1						2						Slack current.
24	13.4	S. S. W.	E. S. E.	1												Do.
25	13.6	E. S. E.		2						1	1	1	16	11	Pass à Louvre.	Slack current; ship Mary E. Riggs, bound in, grounded north side of channel.
26	13.7			3												Slack current.
27	13.7	E.	S. E.	3						1	1					Do.
28	13.6	S. E.	S. S. E.	2						1						Do.
29	13.4	E. S. E.	E. S. E.	1												Do.
30	13.3	N. N. E.	N. E.	1												Do.
1	12.9	E. N. E.	N. E.	4						1						Do.
2	12.9	E. N. E.	E. N. E.	4												Do.
3	12.8	E. N. E.	E. N. E.	4												Do.
4	12.6	E. N. E.	E. N. E.	2						1	3	1	14 0	24	Pass à Louvre.	Slack current; bark New York, bound out, grounded north side of channel.
5	12.6	N. E.	N. E.	3												Slack current.
6	12.8	N. N. E.	N.	3						1						Do.
7	12.9	N. N. E.	N. N. E.	5												Do.
8	13.9	N. E.	N.	2		15	2	17 98								Do.
9	14.2	0	W. N. W.	1	3 30						5					Do.
10	13.8	E.	N.	1	9 15											Do.
11	13.8	N.	N.	3	8 0					1						Do.
12	13.5	N. N. E.	N. N. E.	1	8 40	15	9	17 87		1	1					Do.
13	13.3	N. N. E.	N. N. E.	2						1						Do.
14	13.2	N. E.	N. E.	1						1	1	1	15 0	1	Pass à Louvre.	Do.
15	13.2	E. S. E.	E. S. E.	2												Slack current; steamer Trent, bound in, grounded north side of channel.
16	13.2	N. E.	N. E.	2						3						Slack current.
17	13.1	E. S. E.	E. S. E.	1						1	1					Do.
18	13.1	S. S. E.	E. S. E.	1												Do.

[illegible]

Tabular statement to accompany annual report for the year ending June 30, 1874, &c.—Continued.

Date.	Stage of river at New Orleans—13 m. below high water of 1872. Gauge at foot of Canal street.	Wind at Pass à Loutrie.				Hours worked by dredge-boat.	Depth of channel at extreme low-tide.	Height of high-tide above extreme low-tide.	Total depth of channel at high-tide.	Least width at extreme low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties.				Remarks.
		9 a. m.		3 p. m.									Number of vessels aground.	Greatest draught.	Time of delay.	Locality.	
		Direction.	Force.	Direction.	Force.												
Dec. 3	Feet. 13.4															Slack current.	
4	13.7															Do.	
5	13.5															Do.	
6	13.5															Do.	
7	13.3															Do.	
8	13.7															McAlester went to Southwest Pass for purpose of making survey there.	
9	12.8															McAlester anchored at Southwest Pass; party making survey.	
10	11.8															Do.	
11	11.5															Do.	
12	10.9															Do.	
13	10.7															Do.	
14	10.5															Do.	
15	10.3															Do.	
16	9.9															Do.	
17	9.3															McAlester returned to Pass à Loutrie.	
18	9.3																
19	8.5																
20	8.1																
21	7.7																
22	7.7																
23	7.7																
24	7.7																

REPORT OF THE CHIEF OF ENGINEERS.

695

[illegible]

Tabular statement to accompany annual report for the year ending June 30, 1874, &c.—Continued.

Date.	Stage of river at New Orleans—19 m. below high water of 1872. Gauge at foot of Canal street.	Wind at Pass à Louvre.				Hours worked by dredge-boat.	Depth of channel at extreme low-tide.	Height of high-tide above extreme low-tide.	Total depth of channel at high-tide.	Least width at extreme low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties.				Remarks.
		9 a. m.		3 p. m.									Number of vessels aground.	Greatest draught.	Time of delay.	Locality.	
		Direction.	Force.	Direction.	Force.												
1874.	Ft.	N.	2	N. E.	5 45	164	Ft.	2	Ft.	Ft.	3	1					
Feb. 4	5.5	E.	2	E.	5 45	164	2	164	184	60	3	1					Rough on the bar.
5	5.3	N. W.	2	N. W.	9 30	16	2	18	100	100	3	2	1				
6	4.7	N. W.	2	N. W.	9 40	16	2	18	100	100	3	2	1				
7	4.5	N. W.	2	N. W.	8 0	164			70	70	3	1					Steamer Guillermo, bound out, grounded in channel.
8	4.4	N. N. W.	2	N. W.	8 0	164					3	1	1	20 0	122	Pass à Louvre.	Too rough to work on bar.
9	4.5	N. N.	2	N.	8 30												
10	4.4	N.	2	N.	.....						1	1					Rough on bar.
11	4.3	E.	1	E.	4 40							2					Steamer Guillermo got off bar, and sailed, after detention of five days and two hours. During her detention she was daily assisted by McAlister.
12	4.2	S.	2	S.	7 15						1	2					
13	4.1	S. W.	3	S. W.	9 0						2	1					
14	4.2	S.	2	N.	9 0												
15	4.3	S.	2	S. W.	7 30						1						Brig J. M. Byrne bound in; broke tow-line, drifted to south side of channel and grounded.
16	4.4	S. W.	2	S. W.	5 30	16				40	1		1	12 0	3	Pass à Louvre.	
17	4.4	S. E.	2	S. E.	9 30	164				100	2	2					Coaling; foggy weather.
18	4.5	N.	2	N.	9 0	164				80	4	2					Too rough to work on bar.
19	4.5	S. E.	2	S. E.	9 0	164				80	1	1	4				Too foggy to work.
20	4.6	S. E.	2	S. E.	.....								1				Steamer Tomas bound out, grounded north side of channel with 10 feet water in channel and 10 feet of bar.
21	4.7	S. E.	2	S. E.	.....						2	2					Too rough to work.
22	5.1	S. E.	1	S. E.	.....								1	20 0	94	Pass à Louvre.	
23	5.6	N.	2	N.	.....						1	2					Too rough to work.

24	5.7	N.	5	N.	4				2	4	1	14	0	7	Pass & Loutre.	
25	5.9	N. N. W.	4	N. N. W.	3				3	1						Too rough to work; bark Victory
26	5.7	N. E.	4	N. E.	3				3							about 2,000 feet north of upper
27	5.6	N. E.	2	N. E.	1				1							edge of channel with 19 feet
28	5.8	N. E.	1	S. W.	2				1							water in channel abreast of her.
29	4.9	S. W.	2	S. W.	2				1							Do.
30	4.9	N. W.	2	N. W.	2				50							Do.
31	3.7								50							McAlester started for New Orleans
32	3.5															to repair casing of shaft.
33	3.3															McAlester at New Orleans.
34	3.2															Do.
35	3.2															Do.
36	3.1															Do.
37	3.1															Do.
38	3.0															Do.
39	3.1															Do.
40	3.1															Do.
41	3.0															Do.
42	3.0															Do.
43	3.0															Do.
44	3.0															Do.
45	3.0															Do.
46	3.0															Do.
47	3.7															Do.
48	3.4															Do.
49	3.1															Do.
50	3.0															Do.
51	2.9															Do.
52	2.8															Do.
53	2.8															Do.
54	2.8															Do.
55	2.8															Do.
56	2.8															Do.
57	2.8															Do.
58	2.8															Do.
59	2.8															Do.
60	2.8															Do.
61	2.8															Do.
62	2.8															Do.
63	2.8															Do.
64	2.8															Do.
65	2.8															Do.
66	2.8															Do.
67	2.8															Do.
68	2.8															Do.
69	2.8															Do.
70	2.8															Do.
71	2.8															Do.
72	2.8															Do.
73	2.8															Do.
74	2.8															Do.
75	2.8															Do.
76	2.8															Do.
77	2.8															Do.
78	2.8															Do.
79	2.8															Do.
80	2.8															Do.
81	2.8															Do.
82	2.8															Do.
83	2.8															Do.
84	2.8															Do.
85	2.8															Do.
86	2.8															Do.
87	2.8															Do.
88	2.8															Do.
89	2.8															Do.
90	2.8															Do.
91	2.8															Do.
92	2.8															Do.
93	2.8															Do.
94	2.8															Do.
95	2.8															Do.
96	2.8															Do.
97	2.8															Do.
98	2.8															Do.
99	2.8															Do.
100	2.8															Do.
101	2.8															Do.
102	2.8															Do.
103	2.8															Do.
104	2.8															Do.
105	2.8															Do.
106	2.8															Do.
107	2.8															Do.
108	2.8															Do.
109	2.8															Do.
110	2.8															Do.
111	2.8															Do.
112	2.8															Do.
113	2.8															Do.
114	2.8															Do.
115	2.8															Do.
116	2.8															Do.
117	2.8															Do.
118	2.8															Do.
119	2.8															Do.
120	2.8															Do.
121	2.8															Do.
122	2.8															Do.
123	2.8															Do.
124	2.8															Do.
125	2.8															Do.
126	2.8															Do.
127	2.8															Do.
128	2.8															Do.
129	2.8															Do.
130	2.8															Do.
131	2.8															Do.
132	2.8															Do.
133	2.8															Do.
134	2.8															Do.
135	2.8															Do.
136	2.8															Do.
137	2.8															Do.
138	2.8															Do.
139	2.8															Do.
140	2.8															Do.
141	2.8															Do.
142	2.8															Do.
143	2.8															Do.
144	2.8															Do.
145	2.8															Do.
146	2.8															Do.
147	2.8															Do.
148	2.8															Do.
149	2.8															Do.
150	2.8															Do.
151	2.8															Do.
152	2.8															Do.
153	2.8															Do.
154	2.8															Do.
155	2.8															Do.
156	2.8															Do.
157	2.8															Do.
158	2.8															Do.
159	2.8															Do.
160	2.8															Do.
161	2.8															Do.
162	2.8															Do.
163	2.8															Do.
164	2.8															Do.
165	2.8															Do.
166	2.8															Do.
167	2.8															Do.
168	2.8															Do.
169	2.8			</												

Tabular statement to accompany annual report for the year ending June 30, 1874, &c.—Continued.

Date.	Stage of river at New Orleans—13 m. below high water of 1872. Gauge at foot of Canal street.	Wind at Pass à Louvre.				Hours worked by dredge boat.	Depth of channel at extreme low-tide.	Height of high-tide above extreme low-tide.	Total depth of channel at high-tide.	Least width at extreme low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties.				Remarks.
		9 a. m.		3 p. m.									Number of vessels aground.	Greatest draught.	Time of delay.	Locality.	
		Direction.	Force.	Direction.	Force.												
1874. Mar. 26	Feet. 1.7	E.	3	S. W.	2	.....	.....	.....	.....	.....	1	2	1	15 8	50	Pass à Louvre.	Steamer State of Louisiana, bound in, grounded north side of channel; Esseyons assisting grounded vessels.
27	1.2	E. S. E.	1	E.	2	9 15	.....	.....	.....	.....	1	1	2	18 4	190	do	Steamers New Orleans and Jean, the former bound in, the latter out, grounded, the former above Twin Buoys, the latter in channel abreast of can No. 4.
28	1.6	N.	3	S. E.	2	.....	.....	.....	.....	.....	3	1	2	17 0	1	do	Steamer Geo. Cronwell bound out, grounded north side of channel.
29	1.5	E.	3	S. E.	2	.....	.....	.....	.....	.....	2	2	1	16 2	168	do	Steamer Vixen, bound out, grounded half way between can 4 and Twin Buoys; grounded vessels prevent dredges from working.
30	1.1	S. E.	1	N. E.	2	1 0	16	1	17	50	2	.....	1	17 2	144	do	Steamer Saint Louis, bound out, grounded south side of channel.
31	1.1	S. E.	2	S. S. W.	1	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	do	Grounded vessels prevent work on bar.
Apr. 1	1.0	E.	1	N.	2	.....	.....	.....	.....	.....	1	2	1	.....	.....	do	Grounded vessels prevent work on bar; Esseyons assist grounded vessel.
2	0.9	N.	3	N.	3	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	do	Grounded vessels prevent work on bar.
3	0.8	N.	3	N. E.	3	.....	15	.....	.....	.....	1	2	.....	.....	.....	do	Grounded vessels prevent work on bar; Esseyons assist grounded vessel.
4	0.6	N. E.	1	N. E.	1	.....	.....	.....	.....	.....	1	1	.....	.....	.....	do	Grounded vessels prevent work on bar.
5	0.3	S. E.	4	S. E.	4	.....	.....	.....	.....	.....	.....	2	1	18 9	17½	do	Grounded vessels prevent work on bar; steamers Metropolis, bound out, grounded north side of channel.

6	0.5	S. S. E.	S. S. E.	3	.....	.....	.....	1	1	1	14	0	24	do	Grounded vessels prevent work on bar; ship California, bound out, grounded north side of channel. Grounded vessels prevent work on bar.	
7	0.3	S. E.	S. E.	2	.....	.....	.....	1	1	1	.....	.....	.....	.....do		
8	0.1	S. S. E.	S. E.	4	.....	16	2	18	70	6	.....	.....	.....	.....do		
9	0.0	W.	W.	3	.....	.....	.....	.....	.....	2	1	17	0	552		
10	0.0	N. N. W.	N. N. W.	3	.....	.....	.....	.....	.....	5	.....	.....	.....	.....do	Bark Ragua, bound out, grounded south side of the river, above the light-house, and abreast of north channel.	
11	0.0	N. N. E.	N. N. E.	3	.....	.....	.....	.....	.....	1	5	.....	.....	.....do		
12	0.0	0	0	1	.....	.....	.....	.....	.....	5	2	18	6	24	St'r Germania, bound in, grounded north side of channel; ship Belgravia, bound out, grounded in channel.	
13	0.2	S. E.	S. E.	5		154	24	18	60	3	3	1	18	10	24	Rough on bar; ship Carl, bound out, grounded north side of channel.
14	0.3	S. E.	S. E.	2	.....	.....	.....	.....	.....	3	.....	.....	.....	.....do		
15	0.6	S. S. E.	S. E.	2	.....	.....	.....	.....	.....	3	.....	.....	.....	.....do	Ships Victory and Invincible, the former bound out, the latter in, grounded; the former between Twin Buoya, the latter south of channel.	
16	0.3	S. E.	S. E.	4	.....	.....	.....	.....	.....	1	2	12	0	18	Shack current and rough bar.	
17	0.2	N. E.	N. E.	3	.....	.....	.....	.....	.....	1	5	.....	.....	.....do		
18	0.4	S. S. E.	S. S. E.	3	.....	3	05	154	18	100	4	.....	.....	.....do	Ship Bombay bound out, grounded south side of channel.	
19	0.5	S. S. E.	S. S. E.	1						3	2	1	16	6	12	
20	0.8	N.	N. W.	1	.....	11	0	.....	.....	6	.....	.....	.....	.....do		
21	1.0	N. E.	N. E.	1	.....	.....	.....	.....	.....	1	6	.....	.....	.....do	Rough on bar.	
22	1.0	S.	S.	3	.....	4	15	.....	.....	3	1	13	5	360	St'r Memphis, bound out, grounded in channel, 300 feet above Twin Buoya.	
23	1.2	S. E.	W. S. W.	3	.....	3	35	154	3	184	70	.....	.....	.....do	Essays pulling on Memphis.	
24	1.0	S. S. W.	S. S. W.	5	.....	.....	.....	.....	.....	2	.....	.....	.....	.....do	Do.	
25	1.3	N. W.	N. W.	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do	Essays pulling on Memphis; steamer Margaret, bound out, grounded north side of channel.	
26	1.4	W.	W. S. W.	1	.....	.....	.....	.....	.....	.....	1	13	0	29	Essays pulling on Memphis. Assisting Memphis.	
27	1.5	0	S.	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do	Do.	
28	1.4	S. W.	S. W.	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do	Do.	
29	1.7	N.	N.	3	.....	9	20	.....	.....	1	.....	.....	.....	.....do	Assisting Memphis; she blocks the channel.	
30	1.7	N. E.	N. E.	2	.....	4	30	.....	.....	1	.....	.....	.....	.....do	Unable to work Memphis; she blocks the channel.	
31	1.7	S.	S. E.	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
32	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
33	1.6	S. W.	S. W.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
34	1.6	S. W.	S. W.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
35	1.6	S. W.	S. W.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
36	1.6	S. W.	S. W.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
37	1.5	0	S.	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
38	1.4	S. W.	S. W.	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
39	1.7	N.	N.	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
40	1.7	N. E.	N. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
41	1.7	S.	S.	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
42	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
43	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
44	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
45	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
46	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
47	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
48	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
49	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
50	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
51	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
52	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
53	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
54	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
55	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
56	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
57	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
58	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
59	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
60	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
61	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
62	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
63	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
64	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
65	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
66	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
67	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
68	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
69	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
70	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
71	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
72	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
73	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
74	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
75	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
76	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
77	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
78	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
79	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
80	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
81	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
82	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
83	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
84	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
85	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
86	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
87	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
88	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
89	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
90	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
91	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
92	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
93	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
94	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
95	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
96	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
97	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
98	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
99	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		
100	1.7	S. E.	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do		

* High-water mark of 1871.

† Above high-water mark of 1871.

‡ Below high-water mark of 1871.

; Below high-water mark of 1871.

† Above high-water mark of 1871.

* High-water mark of 1871.

May

30	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
31	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
June	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
1	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
2	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
3	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
4	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
5	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
6	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
7	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
8	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
9	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
10	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
11	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
12	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
13	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
14	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
15	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
16	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
17	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
18	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
19	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
20	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
21	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
22	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
23	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
24	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
25	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
26	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
28	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
29	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.
30	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Do.

R 2.

REMOVING RAFT IN RED RIVER, LOUISIANA.

The progress made on this work is shown by the following extracts from the monthly reports of the assistants in charge:

July, 1873.—Work continued by the Aid and saw-boats from raft No. 32 to No. 35, the latter above Kouns's Canal. The water continued to fall and remained too low to permit the sending of a saw-boat around through O'Rourke's Slough to the foot of raft No. 42, as proposed.

The saw-boats worked in rear of the Aid, and were kept busy sawing the drift pulled from the raft by the Aid's capstan.

Rafts 32, 33, and 34 proved to be among the most difficult of any to remove, but 35 proved to be loose and floating, though filled with large trees. A wide channel in raft No. 41 was made by Hollister's saw-boat. This channel is a fourth of a mile long, extending above Alban's Canal No. 2. On the 17th the party stationed at the head of Dooley's Bayou was sent down the river to begin the work of cutting the willows and impending trees, and removing the snags between Twelve-mile Bayou and Carolina Bluffs. Three men were drowned during the month.

August, 1873.—A channel has been opened from Kouns's Canal to raft No. 39. The length of channel through solid raft opened by the Aid during the month is exactly one mile.

The saw-boat at work on raft No. 41 has opened a channel in that raft a fourth of a mile in length. This raft is less compact than those below Alban's Canal No. 2.

On account of the falling water several jams that have given much trouble formed above Shreveport.

The supply-steamer Kalbaugh was put in order and started for Shreveport on the 8th; the numerous jams delayed her arrival until the 15th. Nitro-glycerine is the effective agent in opening jams, and is carried constantly on the Kalbaugh for this purpose. No fears are entertained by either the captain or crew in its use, and it is considered indispensable in keeping the river open during present stage of water. The work of cutting the impending trees and removing the snags from the river above Shreveport has reached a point above the Hotchkiss cut-off. The low stage of the river causes most of the drift to lodge on the banks; but all that which passes Shreveport is turned into Tone's Bayou as it arrives.

September.—Lieutenant Woodruff was taken sick with yellow-fever on the 15th. No yellow-fever, or unusual sickness, prevailed among the workmen engaged in the removal of the raft. Early precautions were taken to prevent the introduction among the employes of the fever raging in Shreveport, and it is possible their immunity was in a great measure due to the sanitary measures enforced.

Work was continued on raft No. 39, through which an opening was effected by the end of the month. Contrary to expectations, this raft proved to be much harder to remove than any before operated upon. The channel, originally 10 to 12 feet deep, was filled from the bottom to the height of from 3 to 6 feet above the surface of the water with large logs interlaced, and thoroughly compacted by the smaller drift wedged into the interstices. Nitro-glycerine was, for the first time, used in connection with the work of the Aid, in the removal of this raft, and was found most effective. Cans, containing from 10 to 20 pounds of nitro-glycerine, were sunk as near the bottom of the river as possible and exploded, with the effect of breaking the long logs and a general loosening of the mass in the immediate proximity. Small charges were also used in cutting long logs and stumps too far beneath the surface of the water to be operated on by other means.

The low stage of the water during the month has proved an important obstacle to the advance of the work. Jams are continually forming, and the services of the supply-steamer Kalbaugh have been thereby considerably augmented. They increase the difficulties presented in the navigation of the river; and in fact the greater portion of the time of the steamer is consumed in the removal of such obstructions. In this service nitro-glycerine has proved almost indispensable, breaking up the obstructing submerged logs and snags, and liberating the drift lodged against them. These jams are composed of floating drift, which is often piled up far above the surface of the water, and otherwise compacted by the current in narrow places, and often present almost as great obstacles to removal as original raft. Work of removal upon raft No. 41 has continued with fair success. The work of clearing the banks of old river of willows and impending trees has progressed to near Dillard's Plantation.

Lieutenant Woodruff died on the last day of September of yellow-fever. So complete was the isolation from Shreveport of the parties employed on the raft, that the first intimation received by them of the.

death of Lieutenant Woodruff was conveyed through a telegram from the New Orleans office, in which the responsibility of further personal supervision was delegated to Mr. George Woodruff, the brother of the lieutenant, who was, under the circumstances, the most competent person to whom such charge could be delegated. He had been the personal confidant of Lieutenant Woodruff; was therefore thoroughly acquainted with the project for the further prosecution of the work; no interruption to the progress of the work therefore ensued.

October.—Raft No. 40 was removed without much difficulty; the large quantity of drift produced by the operations upon raft No. 41 was liberated by the removal of this raft in its passage down; this drift formed a jam at raft No. 28, which required the united efforts of the crews of the Aid and saw-boats for over three days to remove. The channel made through No. 41 was then improved, and the snags, &c., in the channel between this and raft No. 42 removed. On the 23d the saw-boats were towed into position, and on the following day work was commenced on the last portion of the raft remaining.

A considerable addition to the raft has taken place since the time of the survey. By the end of the month the work of removal had extended to what was the head of the raft in November, 1870, and there still remained to be pulled about two-thirds of a mile.

The work of removal of impending trees, &c., below Carolina Bluffs has progressed favorably.

An obtruding portion of a raft immediately below Dooley's Bayou, and which seriously impeded the passage of drift, was removed, and the channel below in the vicinity improved. The steamer Kalbaugh has been employed in keeping the river open from the Aid to Shreveport, and has proved very efficient in the removal of several very large jams; it has also transported the necessary supplies from Shreveport, and performed other useful work in towing saw-boats, &c.

In breaking the jams and cutting off snags, nitro-glycerine has been found indispensable, from 60 to 75 pounds being used in a day, generally in from 2 to 5 pound charges. For instance, the 31st was almost entirely spent in an unsuccessful attempt to remove a snag under water, which stopped all drift pulled; the last attempt for the day was made with a 7½-inch premium line led to the large steam-capstan of the Aid. The capstan was "stalled." The next morning a 5-pound charge of nitro-glycerine removed the obstruction.

November.—Operations upon raft No. 42 were continued until the evening of the 26th. The river at that time was rising rapidly, and at daylight on the 27th the remaining portion of the raft obstructing the channel went out, and Red River was relieved of a serious obstruction to its navigation. The most important portion of the work having been accomplished, preparation was at once made to return to the foot of the raft and improve the channel existing through the raft. Several extensive jams were encountered on the return to Carolina Bluffs, and several below this. A considerable reduction of the force was effected.

December.—The work of clearing the banks of brush and impending trees was continued below Benoit's Bayou. The Aid, followed by the saw-boats, continued to widen the channel through the raft until the rapid rise in the river, and the blockade at the head of the raft, caused by the timbers of the Fulton Railroad bridge, rendered a return to the head of the raft necessary. After the removal of the obstructions at the head of the raft, the Aid continued to work in the vicinity until the arrival of the order to suspend operations, when the Aid and saw-boats returned to Shreveport, and the crews were discharged. The property stored at Carolina Bluffs was brought to Shreveport and stored with the remainder already there.

No further work of importance was done during the remainder of the year.

During the present year it is proposed to continue the work by keeping the river above Shreveport clear of jams, clearing the banks and removing snags from the bed of the river.

The work is located in the collection-district of New Orleans, and on Red River from Shreveport up. There is no light-house near it.

No commercial statistics have yet been obtained.

A general discussion of the effects of raft-removal is in course of preparation, and will be presented in a separate report, to be rendered some time in November next.

Not having time to treat the subject as fully as I desired, I have placed my notes in the hands of my assistant, Prof. C. G. Forshey, whose professional reputation and long acquaintance with the questions to be considered insure a valuable paper

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$54,000 00
Amount in hands of officer and subject to his check.....	40,141 47
Amount appropriated by act approved June 23, 1874.....	50,000 00
Amount expended during fiscal year ending June 30, 1874.....	94,068 72
Amount available July 1, 1874.....	50,072 75
Amount required for the fiscal year ending June 30, 1876.....	20,000 00

DETAILED STATEMENT OF ORIGINAL, ESTIMATED COST OF THE WORK.

1. One stern-wheel saw-boat, fitted with ten saws on sloping sides and bow, steam-crane, two steam-capstans, with equipage complete.....	\$57,950
2. Flat-boat or scow to receive water-logged raft from saw-boat.....	1,000
3. Stern-wheel tow-boat, with steam-capstans and steam-crane, for unloading scow of saw-boat.....	10,000
4. Double-hull scow, with lifting and sawing apparatus, and small engine for working same.....	15,000
5. Stern-wheel tow-boat for same, with one steam-capstan and steam-crane, for unloading water-logged snags.....	15,000
Total machinery and boats.....	98,950

Estimate for work one year.

No. 1 saw-boat, at \$5,000 per month.....	\$60,000
No. 3, with No. 2, at \$1,000 per month.....	12,000
Nos. 4 and 5.....	20,000
Axe and saw party above raft.....	12,000
Axe and saw party below raft.....	3,000
Repairs of machinery, 10 per cent. on cost.....	9,950
Total work and repairs for one year.....	116,950

Summary for one year.

Boats and machinery.....	\$98,950
Work and repairs.....	116,950
Contingencies, 20 per cent.....	43,169
	259,014

Subsequent expense of keeping river clear of raft and improving channel may be estimated, for first year after opening of channel, \$50,000. Afterward the expense will decrease rapidly, but for several years the work of destroying raft-material and guarding against jams must continue at an annual expense of from \$10,000 to \$25,000.

Whole amount appropriated since commencement.....	\$280,000 00
Amount expended since commencement.....	229,927 25

R 3.

IMPROVEMENT OF TONE'S BAYOU, LOUISIANA.

In my report for last year it was stated that the dam built across the bayou during the year had been undermined and washed away; that a raft formed on the site of the dam had shared the same fate, and that a second raft was being formed.

These rafts were composed of drift from the Red River raft, run into Tone's Bayou, with the primary object of preventing its obstructing the narrow channel of Red River, below the head of the bayou; secondarily with the hope of diminishing the volume of discharge through the bayou, and consequently increasing that through the river.

The raft last formed yet remains in place, but the water has cut under

it, so that the secondary object of formation has not produced any appreciably valuable results in the river.

It is now my opinion that the bayou should be entirely closed by an earthen dam, of the same height as the levees along the river, if it be intended to do anything at this point to improve low-water navigation of Red River between the bayou and Alexandria. Twenty thousand dollars, I think, would construct such a dam, if the work be done at extreme low-water.

My previous reports give my views as to its probable effects; I have but to add that, in the absence of full statistics, my observation during the present low-water in Red River leads me to think that had such dam been put in during the last low-water season, it would have benefited Red River commerce this season an amount greater than its cost. My supplies for the work at "removal of Red River raft" and "Improvement of Cypress Bayou," would have cost me about \$1,000 less than they have so far.

Financial statement.

Amount in hands of officer and subject to his check.....	\$1,007 63
Amount expended during fiscal year ending June 30, 1874.....	989 00
Amount available July 1, 1874.....	18 63

ORIGINAL ESTIMATE.

Bill of material for proposed dam and revetment of Tone's Bayou.—Length of revetment 200 feet on each bank; dam substantially as in plan before furnished:

216 linear feet of 12" by 18" cypress timber, at \$30 per thousand, board-measure.....	\$116 64
2,504 linear feet of 12" by 18" cypress timber, at \$30 per thousand, board-measure.....	901 44
65,000 feet, board-measure, of 3-inch cypress or pine plank, at \$30.....	1,950 00

Sloping pile-revetment.

16,000 feet, board-measure, of 2" by 20" cypress plank, at \$30.....	480 00
Sheet-piling along foot of sloping revetment, 14,400 feet, board-measure; sheet-piling 3" by 12" plank, at \$30.....	432 00
5,760 feet, board-measure; sheet-piling, 3" by 12", at ends of revetment....	172 80
52 piles, 10 feet long, for upper edge of slope-revetment; 52 piles, 15 feet long, for lower end of slope-revetment, and to hold guides for sheet-piling, at lower edge of slope; 104 piles, at \$2 each.....	208 00
800 linear feet of 4" by 8" clamp-pieces to clamp upper ends of lower row of piles, and sheet-piling at foot of slope-revetment, 2,133½ feet, board-measure, at \$30.....	64 00
700 linear feet of 6" by 6" filling-pieces to go between clamp-pieces horizontally between piles of the lower row, to fill space between said clamp-pieces and sheet-piling, 2,100 feet, board-measure, at \$30.....	63 00
Plank binders for upper piles of slope-revetment, spiked on opposite sides of the pile, and above and below the slope-plank, 800 linear feet of 3" by 10" plank, 2,000 feet, board-measure, at \$30.....	60 00
Battens spiked across lower side of upper piles and to the ends of planks which abut against them, each batten 3' long and 2" by 6", 156 linear feet 2" by 6", 156 feet, board-measure, at \$30.....	4 68

Iron bolts.

52 18" iron screw-bolts, ¾" diameter, 340 pounds, at 10 cents.....	34 00
2,000 pounds spikes, at 10 cents.....	200 00
104 cast washers, 250 pounds, at 10 cents.....	25 00
2,000 cubic yards of clay, at 50 cents, for ballast at bottom of dam, upper slope.....	1,000 00
200 cords of riprap for bottom edge of apron of dam and ballast on revetment, at \$20.....	4,000 00
45 E	

Training 2,720 linear feet heavy timber, at 10 cents	\$272 00
Driving 52 short piles, at \$5 each	260 00
Driving 52 long piles, at \$10 each	520 00
Contingencies on cost of material, 20 per cent.	10,763 56
Labor of building dam and revetment after dry basin in river is secured by auxiliary dam	2,152 71
Cost of auxiliary dam, (to which a freshet may add the cost of a second or lower side, or cause suspension of work by backing up water from Bayou Pierre)	10,000 00
Labor, expense of superintendence, and cost of outfit for clearing banks between Tone's Bayou and Loggy Bayou.....	10,000 00
Minimum of appropriation required.....	42,916 27
Whole amount appropriated	20,000 00
Whole amount expended.....	19,981 37

R 4.

IMPROVEMENT OF CYPRESS BAYOU AND CONSTRUCTION OF DAMS AND DREDGING AT THE FOOT OF SODA LAKE, TEXAS.

This work, authorized by act of Congress approved March 3, 1873, is an extension of that commenced under act approved June 10, 1872, appropriating \$10,000 for "the improvement of Cypress Bayou, near Jefferson, Texas."

For report, I divide the work into two parts, as it can best be treated in that way.

I. IMPROVEMENT OF CYPRESS BAYOU.

Cypress Bayou proper is a small stream passing Jefferson, Texas, and debouching into the head of Fairy Lake, and is thence connected with Red River by a chain of lakes generally known as the Soda Lakes.

The work of improvement during the past year has been confined to the bayou. It has consisted in dredging bars, widening and straightening the low-water bed of the stream, removing snags, logs, and stumps from the bed, and protruding logs and overhanging trees from the banks. Incidental to this work there have been made extensive repairs to the machinery employed.

For details, reference is made to the following report of the overseer in charge :

DREDGE-BOAT, CYPRESS BAYOU, TEXAS,
June 30, 1874.

SIR: In obedience to instructions contained in your letter of May 19, 1874, I have the honor to submit the following report of operations for the improvement of navigation of Cypress Bayou, Texas, for the fiscal year ending June 30, 1874.

During the month of July the dredge was lying at the wharf, city of Jefferson, Texas, waiting the arrival of the hoisting-drum and machinery ordered of Messrs. Atkins & Burgess, of Chicago, to replace the one broken in June. The engines, machinery, &c., were overhauled, repaired, and put in proper condition for work. A new swinging-circle was made for the head of the mast and put on; the crane was repaired and put in order, and such other repairs about the boat as were considered necessary were made, the work being done by the crew of the dredge.

The new hoisting-drum ordered from Chicago did not arrive until July 21, 1874.

The unfinished condition in which the drum and castings were received from the makers caused a delay of several days in fitting them so that they would work. The dredging was not commenced till July 29.

It was the original intention to complete dredging the channel from Boon's Bend to the city wharf, a distance of about three miles. The distance was not quite two-thirds dredged when the season of high-water came on and made it necessary to discontinue

the work or move the dredge up the bayou to the more shallow places, which was done according to instructions received from the late Lieut. E. A. Woodruff.

At the time of the breaking of the hoisting-drum, in June, the dredge was at work a short distance below the city wharf, on a shallow point or bar.

During the interval of waiting the arrival of the new drum from Chicago the water had fallen so much that it was impossible to get the dredge back down the bayou to resume operations where the work had been interrupted by the high water without dredging a portion of the way to that place, the dredge drawing $5\frac{1}{2}$ feet, and at places there was only $3\frac{1}{2}$ to 4 feet of water in the channel. Under these circumstances it was deemed advisable to complete dredging the channel in the vicinity of the wharf. Considerable dredging was necessary to make a good and permanent channel to the lower end of the wharf, on account of the bayou being very shallow and having a bend in it, requiring a dredging of two cuts, or double the usual width the most of the distance, so that boats in making the bend would have sufficient room and water to do so with very little trouble.

On the evening of the 29th of August the hoisting-drum was again broken. Another one was immediately ordered from Chicago by telegraph.

The new drum was ordered to be made much heavier and stronger than the one previously furnished, and to be warranted to stand one year without breaking, which the makers agreed to do, and to be ready for shipment in ten days from date of receiving the order. Owing to the yellow-fever epidemic at Shreveport, La., and the establishment of a rigid quarantine on all the lines of communication to this place, the arrival of the second hoisting-drum was delayed until October 27. On receiving it on board it was got into position and dredging resumed as soon as possible.

While waiting for the drum the crew of the dredge were employed in making repairs and improvements on the boat, overhauling the engines and machinery, rebabbitting the journals or boxes of the engine-shaft, and shafts of the hoisting and swinging drums.

A new boom was made and put in the crane, a new swinging-chain was put up, the siphon repaired and new pipe put in, also pipes put up connecting the boiler with the feed-pump pipe, to be used as a heater to prevent the pipes from freezing up. A new smoke-stack was made and put over the forge; a flat-boat was built for carrying wood from the bank to the dredge; and, among other repairs, a tin roof has been put on the cabin.

By the middle of December the channel, from the first deep water below the city to the lower end of the wharf, was completed, and the dredge moved down the bayou to the shallow point above the railroad-landing, a distance of about three-quarters of a mile from the city, and the dredging out of this place commenced.

During the time the dredging of the channel in the vicinity of the wharf was being done, teams and laborers were employed to remove from the bank of the bayou some 7,000 cubic yards of excavated earth to prevent its being washed back into the bayou during the high-water season.

The earth removed was about two-thirds of the quantity excavated, and that only that had been thrown out on the right-hand bank while dredging up-stream. Before the whole of the earth could be removed the water rose, covering the greater portion of that remaining.

Having completed dredging the channel between Boon's Bend and the city, the dredge was taken down the bayou some eighteen or twenty miles to the Benton Cut-offs.

There are two cut-offs at Benton. Work was commenced on the lower one, it being the shortest, and, by dredging a channel from 100 to 150 yards in length, cut off about a mile of very difficult navigation.

The upper cut-off is considerably longer, and saves following the channel of the bayou for about the same distance as the lower cut-off.

By the time I had finished dredging the short cut-off, which was in the latter part of March, the high-water made it impossible to continue the work any longer. The probability of the water remaining high for a considerable time decided me to take the dredge back to Jefferson and have the engines and the machinery overhauled and repaired, the decks and sides of boat calked and pitched, and the new crane-machinery, new dipper, and new chains that had been ordered, and were in Jefferson, put into position. The old dipper and chains were badly worn and broken.

In order to disconnect the old dipper and put the new one in its proper place, it was necessary to have the dredge by the side of the wharf or some high bank, as they weigh about 4,000 pounds each, and would be awkward to manage and get into place without the proper facilities for doing so.

During the high-water season, which lasted about eight weeks, the dredge was kept lying at the wharf and undergoing thorough repairs, the crew doing the work.

The new hoisting and new arm chains were put on, and everything about the boat was put in as good condition as possible, ready to resume operations as soon as the stage of the water would permit.

The water did not recede to the ordinary stage, or within the channel proper, till

about the 1st of June. On the 8th of June I started from Jefferson with the dredge, down the bayou, for what is known as "Dorherty's Defeat," about four miles below Smithland. Here the banks are low, and the bayou spreads out over the country for some distance, and is quite shallow in many places, and makes a number of short bends. There are also many stumps along the channel and in the shallow places that give much trouble to boats, especially in the low-water season.

That portion of the bayou called "Dorherty's Defeat" is from one-half to three-fourths of a mile in length, but the whole distance is not low water, only in places.

By dredging a channel through the low-water portions and cutting off several short points or bars, thereby making the bayou straighter, and removing the stumps from the channel, the navigation will be materially improved.

After finishing the work at this place, (Dorherty's Defeat,) which will require two months' time, or more, the next place of any importance in the bayou, between Jefferson and its mouth, requiring dredging is the upper Benton Cut-off.

I considered it better to complete the work of dredging the channel of the bayou as the dredge worked toward the lakes.

My reasons for passing over Dorherty's Defeat, when taking the dredge below last February, was, the water was then too high to work to advantage and to be able to find and remove all the stumps.

To cut a channel across the upper cut-off at Benton will take considerable dredging, as the distance is more than twice that of the cut-off already dredged.

Upon completion of the work at Benton no more dredging in the bayou will be necessary, at least for some time, that I am aware of.

However, there are some places in the bayou where the channel will fill up in a much shorter time than in others on account of the light sandy nature of the soil and the peculiar shape of the stream, and, in my opinion, it will be found necessary to dredge out these localities every year or two.

If the excavated earth could have been deposited at a greater distance from the edge of the bank it would have prevented the filling of the channel as soon as otherwise.

The navigation of the bayou will be comparatively easy at the ordinary low stages of the water for steamboats of the class usually running upon these streams.

Judging from what I have seen and learned regarding the work required in the lakes, especially in the vicinity of the Bois d'Arc Passes and the Blind Bayou, in the upper end of Fairy Lake, I am of the opinion that navigation could be greatly improved by working the dredge there, in straightening the channel, and taking the stumps out, which are the principal obstructions to be removed. As for the length of time that would be required to do the work at these places, I could not say.

In the month of February 1,000 pounds of nitro-glycerine was purchased for the purpose of blowing up and removing stumps and logs that are in the bottom of the channel, and are found to be too large and heavy for the dredge to get out without the risk of breakage of machinery and loss of time. From the experiments I have made with it, and the benefit derived from its use in the work of removing the Red River Raft, there is no doubting its efficacy, and I am confident the use of nitro-glycerine in removing these large cypress stumps and logs will be of great advantage to the work, as the breakage of machinery in pulling these stumps has caused serious delays.

The following statement shows the amount of excavations made each month the dredge was in operation:

During the months of July, September, and October the dredge was not at work on account of breakage of hoisting-drums; and during the months of April, May, and part of June, work was suspended by reason of high water.

Months.	Length.	Average breadth.	Average depth.	Cubic yards excavated.	
	Feet.	Feet.	Feet.	Yards.	Feet.
August.....	838	45	7	9,456	14
November.....	516	45	6 + 10	8,588	24
December.....	868	45	7	8,586	18
January.....	858	45	7	18,304	12
February.....	720	45	7 + 10	7,730	24
March.....	400	45	7	4,066	12
June.....	380	40	6 + 10	4,437	11
Total.....	4,580	45	6 + 10	53,730	17

I have the honor to be, very respectfully, your obedient servant,

FRANK W. GEE.

Capt. C. W. HOWELL,
Corps of Engineers, U. S. A.

II. CONSTRUCTION OF DAMS AND DREDGING AT FOOT OF SODA LAKE.

In his report of April 29, 1872, which was a preliminary report on a survey of Cypress Bayou, and made before the operations of the survey were fully completed, Lieutenant Woodruff recommended the construction of certain dams, at the foot of Soda Lake, to confine the low-water discharge at that point to a single narrow channel or chute. The appropriation of March 3, it is believed, was based on this recommendation.

In his final report on the survey, (page 669, Report of Chief of Engineers for 1873,) Lieutenant Woodruff states that the supposition on which he based his first recommendation he afterward found to be entirely incorrect, and recommends the substitution of a lock and dam for the dams previously projected. In submitting this report to the Chief of Engineers, I stated that I was not prepared to indorse the plan and had directed further investigation. This investigation Lieutenant Woodruff was directed to make during the season of extreme low-water in the fall of 1873. Preparations for the work had been made, and it is presumed that the visit to Shreveport, resulting in his death, was made by Lieutenant Woodruff with the intention of proceeding with the examination. Finding himself in the midst of an epidemic; unable to get assistants; having been exposed to disease; and unwilling to risk carrying that disease among his employes at work on Red River raft, he did what was proper, prudent, and humane, though his action cost him his life. His death suspended the investigation directed, and it was late in December, 1873, before a party could be placed in the field to make it.

In December, Mr. H. A. Leavitt, assistant engineer, was employed to make the survey, the field-work of which was completed March 10, 1874. The work was plotted, and Mr. Leavitt's report, with plans and estimates, available at the close of May. It was then too late in the season to commence work on the plan suggested, even had the amount of appropriation available warranted.

Pending investigation and survey above reported, it was proposed, in place of dredging at the foot of Soda Lake, to remove stumps and logs from the channel through the foot of the lake, and Lieutenant Woodruff was instructed to avail himself of the first favorable stage of water for doing this work. For the reasons stated above, the favorable season of 1873 was lost and the project abandoned for the year.

With the light we now have it must appear well that money has not been expended on either of the three projects named above.

It is now possible for me to submit a definite plan for the improvement desired, and in doing so I will first present a description of the navigation from Jefferson to Shreveport, and afterward a discussion of the several plans for improvement that have been considered.

DESCRIPTION.

Jefferson, Texas, is at the head of navigation in Cypress Bayou. From that point down to the head of Fairy Lake, a distance of twenty-seven miles, the Bayou, at low-water, is narrow, tortuous, and before improved was shallow and greatly obstructed by timber. Fairy Lake, from its head for about half its length, is thickly studded with cypress-trees, stumps, and fallen timber, through which the old channel of Cypress Bayou may yet be traced at low-water, and this, if cleared of logs and stumps, would afford low-water navigation of about 2 feet.

In high-water this channel is partly followed by steamboats, and

partly avoided by use of what are known as "cut-roads." The lower half of the lake affords a navigation of over 6 feet.

At its foot the lake enters the valley of Red River between bluffs but 1,480 yards apart. At this point it meets the whole discharge from Red River that is made by the latter through breaks in its western bank between Hurricane Bluff (directly opposite the foot of the lake) and Blanton's Landing, twenty-two miles above.

January 1, 1872, when at Albany Point, the water-surface was 6 feet above extreme low-water; the surface at this point was found 2.3 feet below the surface of Jefferson, (twenty-five miles distant in a straight line,) 38 feet below the surface of Red River at Blanton's Landing, (twenty-two miles distant,) and 11 feet below that at the nearest point on Red River, (five miles distant.)

The great body of water concentrated at this point finds vent through Willow Pass into Soda Lake, giving the pass a depth of from 20 to 30 feet, but at its foot, where the water spreads into Soda Lake, forming a bar having over it only a depth of about 2 feet at low water. Through the lake there is a depth of from 3 to 5 feet, and at its foot a wide shoal, known as Albany Flats, with a depth of but 1 foot at extreme low water.

This lake forms a settling-basin for the Red River water drawn through it. The slope of its water-surface at the date before stated was but $1\frac{1}{2}$ inches to the mile. It is gradually filling up with Red River deposit.

Below Albany Point the old channel of Cypress Bayou is well defined, and affords good low water navigation through the upper portion of Cross Lake, Twelve-mile Bayou, and Red River, to Shreveport.

At Albany Point, January 1, 1872, the surface of the water was 6.3 feet below the surface in Red River at the nearest point, 2.3 miles distant. At the head of Twelve-mile Bayou the water-surface was 2.8 feet below Red River opposite, a distance of 704 yards.

The fall from Albany Point to Shreveport was 11.8 feet; from Red River, opposite Albany Point, to Shreveport, 18.1 feet.

From this it appears that the foot of Fairy Lake is the center of a basin, having Red River on one side and the line of bluffs to the west of it on the other. [This is better shown by the chart inclosed, marked (A).]

The raft in Red River, along the eastern rim of this basin, deflected the greater portion of the river-discharge above the raft into the basin, thus converting what before the advent of the raft was a cypress-swamp, with a sluggish, unnavigable stream flowing through it, into a series of lakes, affording good navigation for the greater portion of each year.

It is feared on the part of the commerce interested that the removal of the raft will immediately effect a shortening of the season for this navigation, and perhaps ultimately return it to its original condition.

It is too early to determine if such fear be well grounded.

It is desirable at present to obtain a 3-foot low-water navigation from Shreveport to Jefferson; this is probably as much as will ever be required. To obtain this the following plans have been considered:

1st. Dredging.

2d. Wing-dams at Albany Point.

3d. A lock and dam at Albany Point.

4th. A tumbling or other dam at Albany Point, with a cut into Red River.

5th. A dam across Willow Pass, at the foot of Shift-tail Lake, and the re-opening of Irishman's Bayou.

6th. A dam in Cross Lake and Twelve-mile Bayou, with a cut from near the head of this bayou to Red River.

The following consideration of these several plans is submitted.

DREDGING.

Beginning at Albany Point, on a straight line through Soda Lake, the distance to deep water in Willow Pass is about eight miles; over this line the depth at low-water varies from 1 to 5 feet. This is the line that apparently should be adopted for a dredged channel through the lake, for the reason that, except through a very short portion of the lake, (about one-quarter its length,) the old channel of Cypress Bayou has been obliterated by deposit, while that portion that may yet be traced is so narrow and tortuous that it would require widening and straightening by dredging to put it in good condition.

Dredging on the straight line indicated, to obtain a 3-foot channel, would require excavation to a depth of about 2 feet for one mile over Albany Flats, and excavation of about 1 foot, for the same distance, at the foot of Willow Pass; a total excavation of about 35,200 cubic yards for a channel 60 feet wide.

The excavation would run through the remains of a Cypress Swamp, and would consequently be very expensive. Further, it has been shown by the surveys made that Soda Lake is the main settling-basin for the Red River water passing through it.

The deposit in this lake has been so great as to entirely cover the knees of the cypress yet standing in the lake, while in the other lakes these knees are yet uncovered.

The depth of such deposit was not ascertained, nor is it known for how long a time it has been forming, but the covering of cypress-knees indicates a thickness of several feet, and the living trees at points in the lake show it to be a very recent formation. The inference is that since the cause of deposit does and will continue, any dredged channel through the lake must sooner or later be silted up. If, then, dredging be resorted to, the depth should be made considerably greater than actually necessary for the time being, in order to avoid annual dredging to keep the channel open.

I assume, therefore, that the depth of a dredged channel through Soda Lake should be 6 feet at extreme low-water; this would make an average dredging of about 2 feet, sixty feet wide, for a distance of eight miles, equal 563,200 cubic yards of excavation. This, of itself, appears sufficient to condemn dredging, but when there is added to it the dredging that would have to be done in the upper end of Fairy Lake and across the bar at the present mouth of Cypress Bayou, it is clear some other plan of improvement should be considered.

WING-DAMS AT ALBANY POINT.

This was Woodruff's first recommendation. He afterward found that the chutes he proposed to close with dams were so nearly dry at low-water that but little, if any, concentration of low-water discharge would be effected by the dams, and that consequently they would be of little or no use in holding the last stages of a flood in Soda Lake to prolong navigation through it.

LOCK AND DAM AT ALBANY POINT.

This was recommended by Lieutenant Woodruff in his final report of survey of Cypress Bayou, and the plan was well calculated to give at all seasons a depth of 6 feet from Albany Point to Jefferson. Having doubts of its low-water effects below Albany Point, I have awaited the results of the further survey ordered before considering the project.

The survey of Mr. Leavitt, besides disclosing difficulties of foundation not anticipated by Lieutenant Woodruff, shows that without the interposition of a second lock and dam between the first and Shreveport, in low-water the bayou and lake below Albany Point, for a distance of nearly 6 miles, would run dry. This is best shown in section on Leavitt's chart herewith, (marked B.)

The first lock would require a lift of 10 feet, the second a lift of 13 feet, at low-water of 1873 at Shreveport, to make 3-foot low-water navigation from that point to Jefferson.

The walls and gates of the locks would have to be 26 feet high in order not to be overtopped at a stage of water equal to the high-water of 1866, the highest of which we have record.

In view of the above, the project was rejected, and it was not considered necessary to make detailed plans and estimates for it.

DAM AT ALBANY POINT AND CUT INTO RED RIVER OPPOSITE.

Woodruff's survey showed the whole fall from Jefferson to Albany Point to be but 3.5 feet at a time when there was 4-foot navigation over Albany Flats. Of this fall, 2.3 feet was from Jefferson to the head of Fairy Lake. The lake was a level; from the foot of the lake to Albany Point the fall was 1.2 feet.

By placing directly across the water-way at Albany Point a dam having its crest 14 feet below the local high-water mark of 1866, there will be given over Albany Flats a depth of about 6.5 feet, whence, from the above, it is evident there will be given to the foot of Fairy Lake a least depth of 5.3 feet, and from thence to Jefferson a least depth of 3 feet throughout the year.

It is considered that the latter depths will be greater than stated, for the reason that the slopes reported will not probably be very greatly diminished; also, no allowance is made for the dredging from Jefferson to the head of Fairy Lake, a distance in which the greater fall occurs, for the reason that it is anticipated that the dredged places will fill in a few years.

For perfect safety the figures are based on a level from Albany Point to Jefferson.

As such dam, while answering the purpose of giving good navigation above it to Jefferson, would effectually cut off the navigation below from that above, it would be worse than useless, except a new connection be made with Red River. A cut to Red River from a point above the dam is therefore necessary as a portion of the project.

The difference in level of water-surface between Soda Lake at Albany Point and of Red River (opposite) at Gold Point renders such connection practicable without lowering the surface created by the dam, as shown by the following:

Our surveys indicate the fact that during all seasons of the year the surface of the lake at Albany Point is lower than the surface of the river opposite at Gold Point, viz, at high-water of 1866, when there was between 19 and 20 feet over Albany Flats, the lake-surface was 2.38 feet below that of the river.

In 1872, with 4 feet over the flats, it was 6.3 feet below; and in 1867, with between 2 and 2½ feet over the flats, it was 3.8 feet below.

Although no observation was made to determine the difference of level at extreme low-water, viz, when there is but one foot of water over the flats, it is assumed that this difference is probably not less than 2 feet,

inasmuch as the measurements given were all made before the removal of the raft.

Under this assumption the proposed dam and cut should give at all seasons of the year 3 feet navigation over Albany Flats, a sufficient depth for the present, since the river below Shreveport only affords a depth of 20 inches during low-water; and it is not the local trade between Shreveport and Jefferson that is to be served by improvement, but the trade between the Mississippi River and Jefferson.

Besides the improved navigation it is designed to give above Shreveport, this project presents another subject for consideration.

It is claimed that in case the removal of the raft should prove to effect a shortening of navigation through the Soda Lakes, it will also shorten the season below Shreveport.

This is on the supposition that the lakes serve as reservoirs to detain floods of Upper Red River, so that they are longer in passing Shreveport than they would be if these reservoirs did not exist. If this be true, then the reservoirs are useful in lengthening the season of navigation below them.

The plan of a dam and cut at Albany Point appears to present the means not only for preventing any possible deterioration of these lakes as reservoirs, but also a probable means for increasing their efficiency.

In connection with this three plans for a dam have been considered, and these require notice.

1st. A tumbling dam, having its crest 14 feet below the local high-water mark of 1866. This is the one so far assumed for illustration, and the one called for if navigation above it is alone to be considered.

In this case there is but one objection to it, and that may be overcome by a suitable construction. The objection is this: The character of the foundation offered for a tumbling dam is not favorable to permanence of the structure, the soil being of an easily abraded mixture of sand and clay, with strata of sand at intervals. During low-water the bed of the lake at the foot of the dam will be dry, while just above, on Albany Flats, there will be from 3 to 6 feet.

At the commencement of a rise, when the water begins to flow over the dam, the fall over the several portions of the length of the dam will range from zero to 15 feet. It will afterward be some time before the lake below fills sufficiently to afford a useful water-cushion to break this fall. At extreme high-water the surface of the upper lake will be from 10 to 14 feet above the crest of the dam, and the lake below will probably be filled to nearly the same level; during the intermediate stages we must expect powerful eddies about the foot of the dam.

These facts suggest difficulties of construction which may certainly be overcome, but at great expense, and by taking every precaution to have workmen and material on hand so as to begin and complete the work in a single low-water season, the length of which may only be safely assumed at 4 months, and those 4 months the most unhealthy of the year.

If we further look to this dam as a means for increasing the efficiency of the Soda Lakes as reservoirs, then it must appear too low to have any appreciable effect, for it has been shown that during all except the lower stages, water must run from Red River to the lake rather than from the lake to the river, while after the lake has fallen to the crest of the dam, and further discharge must be into the river, the possible fall of three feet, taken in connection with the area of the lake, indicates such a small volume of discharge that it does not need figures to prove it of no value below Shreveport.

2d. A dam from Albany Point to the bank of Red River, having its crest 2 feet above the high-water of 1866, on Red River.

As the first plan of dam is the minimum allowable for improved navigation, so this plan appears to offer a maximum for reservoir effect.

It would throw the whole of the lake discharge into Red River through a channel which (following its meanderings) would be 7.6 miles longer between Albany Point and Shreveport than the present route via Twelve-mile Bayou, and 9.1 miles longer than the route via Cross Bayou.

This difference in length would necessarily retard the emptying of the reservoir, but on the other hand we should lose an important portion of the present effect of Lower Cross Lake. The latter would then be only a reservoir in proportion as the water was ponded back into it from Shreveport, whereas now it holds a large volume of the flood-waters received through the Sodo Lakes, for a time after the latter have well run out. This is evidenced by Leavitt's survey, and a section displayed on his chart, where it is shown that the water-surface in the neck between Upper and Lower Cross Lake was 3 feet above the surface in Twelve-mile Bayou, 540 feet distant, and the same above Red River, just above.

It is questionable if the gain on the one hand would not be balanced by the loss on the other.

There is another and more serious objection to the plan, viz: The river between the dam and Shreveport has not the capacity to carry the volume to be added from the lakes, and to give it the capacity would require radical changes in its bed, involving the destruction of many plantations.

These two considerations condemn the plan of a high dam.

3d. A dam across the foot of Soda Lake, having its crest of the height of No. 2; the crest between the lake and river to be depressed to 9 feet below the high-water of 1866.

This is a compromise between the 1st and 2d, and while offering the advantages possessed by both, permits the filling of Cross Lake by direct overflow, and it is thought will not seriously affect the plantations along the river bank.

This is the plan recommended in my communication of May 1, transmitted to the Chief of Engineers in answer to the inquiries of the chairman of sub-committee of House of Representatives on rivers and harbors.

It is the plan I recommend for adoption on two conditions, viz:

1st. That the money required to carry it out be all appropriated before the work is commenced.

2d. That the commerce to be benefited be found to warrant the expenditure. Of this I do not pretend to judge.

The other two plans considered call for but brief mention.

5th. The fall from Red River, through Irishman's Bayou, to the foot of Fairy Lake, January 1, 1872, was 11 feet. It is evident that a dam crossing the head of Sodo Lake, Willow Pass, passing around the foot of Shift-Tail Lake, and connecting with the bank of Irishman's Bayou, might be constructed the same as at Albany Point, and to answer the same purposes.

The length of the dam, as indicated on Woodruff's chart, and its great height, due to the depth of Willow Pass, together with the labor of re-opening Irishman's Bayou, which is filled with raft, shoal, narrow and tortuous, condemns the project, further by cutting off the settling basin afforded by Soda Lake, a great deposit would be induced above the dam, making in a short time, it is anticipated, a second Albany Flats.

6th. Mr. Leavitt suggested a dam across the neck between Upper and Lower Cross Lakes, thence across Twelve-mile Bayou to the bank of Red River, and a cut from the bayou above into the river. This was rejected because of the dimensions of the dam required and the insufficient fall from the river to the bayou, the latter being so slight that it could not have effected the depth over Albany Flats.

The location at Albany Point appears to be a proper mean between the two locations last named.

CONSTRUCTION OF DAM-MATERIAL.

The neighboring country affords an abundance of cypress timber, which may be delivered in rafts at the site of the work during high-water. Albany Bluff affords a good clayey soil. Albany and the neighboring bluffs will furnish, it is thought, enough stone (of a quality not suitable for masonry) that will answer for ballast. No other material for construction can be had except from a great distance and at great expense.

The dam must therefore be mainly built of timber.

A pile-dam, judging from the fate of that built across Tone's Bayou, would probably not stand long.

A framed dam would be difficult of construction, costly, and offer no better hope of permanency than one made by piling.

In the Red River raft we found numerous large islands, (comparatively speaking,) formed by an accumulation of timber, cemented together by river-deposit and the roots of willows; these were able to withstand the full force of the river-current during the floods and were difficult of removal by machinery, even when aided by nitro-glycerine.

It is proposed to imitate this natural formation, as is best shown by the drawings herewith, by building a dam with untrimmed cypress-trees, placed butts down-stream, layer over layer, with the interstices filled in with earth from the bluff, and the top and apron ballasted with stone.

On this plan the cost of a tumbling-dam, No. 1, is estimated at \$57,661, viz:

4,437 trees, (in place,) at \$4.....	\$17, 736
1,576 cubic yards earth, (in dam,) at 50 cents.....	788
10,120 cubic yards ballast, (in dam,) at \$3.....	30, 360
Add 20 per cent. contingencies.....	9, 777
Total.....	57, 661

The cost of dam No. 3 is estimated at \$217,314, viz:

24,896 trees, (in place,) at \$4.....	\$99, 584
75,950 cubic yard earth, (in dam,) at 50 cents.....	37, 975
20,000 cubic yards ballast, (in dam,) at \$3.....	60, 000
Add 10 per cent. contingencies.....	19, 755
Total.....	217, 314

NOTE.—Only 10 per cent. is added in this case because of the magnitude of the work and its offering no more under-water work than No. 1 does.

THE CUT.

The place of the cut is indicated on Leavitt's chart. The estimated excavation for it is—

467,170 cubic yards, which, at 30 cents per cubic yard, will make it cost.....	\$140, 151
Add 10 per cent. for contingencies.....	14, 015
Total.....	154, 166
Total cost of dam No. 1 and cut.....	211, 827
Total cost of dam No. 3 and cut.....	372, 580

The estimate for the dam is based on the assumption that all material for it is to be collected, so that the dam may be constructed during a single low-water season.

The estimate for the cut is based on a width of 60 feet at top, 30 feet at bottom, and a uniform depth of 6 feet below low-water mark.

It is thought that perhaps a cut of lesser dimensions may answer, on the supposition that the currents through it may scour it wider and deeper. This consideration, however, could not be made to safely enter the estimate.

The following report of Mr. Leavitt contains such commercial statistics as I have been able to collect :

Report of Mr. H. A. Leavitt, Assistant Engineer.

NEW ORLEANS, May 28, 1874.

CAPTAIN: I have the honor to submit the following report of survey of that portion of Cypress Bayou known as Soda Lake and Twelve-mile Bayou :

The field of operations extends from Albany Flats, four miles from the foot of Soda Lake, to Shreveport, La., a distance of some seventeen miles.

The field-work was commenced January 5, 1874, and completed March 10, 1874, having occupied a little over two months.

Before completing the organization of my party, I spent two days in making a preliminary examination. Owing to the high stage of the water, and the probabilities of a still further rise, I concluded to begin my work at Albany Point, with a view of ascertaining the cost of a lock and dam located at that point, as recommended by Lieutenant Woodruff, assuming that to be the only way in which the difficulties of Albany Flats could be overcome.

On January 10, having perfected my organization, I went into camp at Albany Point, and established gauge, taking readings morning and evening until the close of the survey.

My progress was very much hindered by the dense growth of timber which lines both shores of the lake and islands, and much time was lost in clearing sights. Had the survey been made during low-water much more work could have been done and with better results.

The field-work of Soda Lake was made from a base-line located one-half mile above Albany Point, and, where opportunities offered, tie-lines were measured as checks on the work.

For the line down Twelve-mile Bayou the stadia was used.

Accompanying this report are—

1st. One general map, showing the country in the field of operations, with sections at Albany Point, Cross Lake, and Twelve-mile Bayou, also section through channel from the flats to Shreveport, with water-slope of January 20, 1874.

2d. Detailed drawings of proposed dam, showing front elevation, plan, and sections. The soundings are reduced to gauge-readings of January 20, that being the date of the lowest stage during time of survey. The highest water-mark of 1866 was obtained from Mr. Howe, who has lived at Albany Point for some twenty years. The mark shown me was a stake driven in the ground near a stump which protected it from anything that would be likely to disturb it. I compared it with well-defined marks found on the timber at the head of Blind Bayou and found them to agree very closely. The extreme low-water mark on Albany Flats is not so reliable. I was obliged to depend on the statements of parties of whom I made inquiries. I was informed that during low-water "one could wade anywhere on the flats without getting their feet wet," and that navigation even by skiffs was a matter of difficulty.

With the above uncertain information I assumed one foot on the flats to be very near extreme low-water.

I obtained from the Signal-Service office at Shreveport the record of the gauge for the time during the survey, and from the files in this office the high and low water for 1873.

The section shown by dotted red line on map through channel from Albany Flats to Shreveport was fixed by triangulation from base and shore lines, after careful soundings at right angles; across the channel signal-flags were put up in the deepest water found.

This channel is used by all boats, when there are 6 feet and less on the flats; at 6 feet and over, what is known as the "Cut Road," and indicated on the map by dotted black lines, from Albany Point to the "Gate Post," is used; it is of little benefit, however, to navigation, as the saving in distance over the crooked channel of the bayou will not compensate for the risk run in "picking up stumps."

The Cnt Road, as the term indicates, consists in chopping the standing timber during low-water, and is resorted to very often in the lake-navigation to save distance during high-water.

The fall, as shown by water-slope, is 11.82 feet when there is 6 feet of water on the flats; at extreme low-water it is 18.24 feet, and for high-water of 1873 it is 8.85.

The section shown in blue, and marked Leavenworth's section, is submitted to show the difference of level between Sodo Lake and Red River, October 20, 1867, and high-water of 1866.

After completing survey in vicinity of Albany Point, I located a line shown in red, and by section C D, for the purpose of making estimates of proposed lock and dam. Borings were taken to a depth of 34 feet, and specimens preserved wherever a change of material was found.

Sections of borings are shown, and the materials and depths found marked.

The following table of difference of level between Albany Point and Shreveport is submitted to show that should a lock and dam be constructed at Albany Point, another would be required located near the mouth of Twelve-mile Bayou to hold navigation good to that point.

The zero of the United States gauge at Shreveport is taken as the plane of reference.

Date.	Gauge, Albany Point.	Gauge, Shreveport.	Difference of level.	Date.	Gauge, Albany Point.	Gauge, Shreveport.	Difference of level.
1874.				1874.			
January 15.....	27.64	16.82	10.82	February 8.....	29.46	19.93	9.53
16.....	27.49	16.65	10.84	9.....	29.81	20.42	9.39
17.....	27.28	16.32	10.96	10.....	29.97	20.67	9.30
18.....	27.14	16.07	11.07	11.....	30.09	20.93	9.16
19.....	26.96	15.73	11.23	12.....	30.17	21.17	9.00
21.....	26.89	15.07	11.82	13.....	30.59	21.50	9.09
24.....	26.94	15.00	11.94	14.....	30.70	22.00	8.70
25.....	26.90	14.67	12.23	15.....	30.83	22.33	8.50
26.....	26.94	15.07	11.87	16.....	30.83	22.58	8.25
31.....	27.39	16.17	11.22	26.....	30.84	22.33	8.51
February 1.....	27.57	16.73	10.84	March 4.....	32.14	23.58	8.56
3.....	28.00	17.44	10.52	High-water, 1873.....	36.34	27.49	8.85
6.....	28.91	19.90	10.01	Low-water, 1873.....	21.89	3.65	18.24

As the plan assumed to overcome the difficulties of Albany Flats by lock and dam, from the nature of the foundations, scarcity of material for ballast, and the necessity of a similar structure in Twelve-mile Bayou was thought too expensive, and the construction attended with many difficulties, I was led to examine some other method more safe and reliable.

I extended my survey down Cross Lake to a point offering very favorable advantages for the construction of a dam. The width of Cross Lake at this point is 1,025 feet, and completely filled with cypress stumps from 2 to 4 feet in diameter and standing some 6 feet above ordinary stage of the lake, presenting a firm anchorage. The west shore of the lake is very abrupt, with an elevation of 40 feet above the water. Sections of Cross Lake and Twelve-mile Bayou are shown, and marked E, F, A, B.

The plan proposed would be a high-water dam, crest of dam 2 feet above highest known water, located on line E, F, A, B, and extending 1,600 feet from B. Total length of structure, 2,600 feet; and a channel cut from Twelve-mile Bayou to Red River on line L, N, section shown. Length of cut, 1,100 feet.

The construction of the dam is shown by the detail-drawings, and consists of trees and earth, the west shore of the lake furnishing both materials in abundance. The trees would be taken just as they fall from the stumps and placed in position, the tops up-stream and butts resting on timbers placed parallel with line of dam. After placing one layer in position as closely as possible, the spaces are filled with clay, well rammed. This is repeated until the desired elevation is obtained. The front slope is $2\frac{1}{2}$ to 1, and rear 1 to 1.

The distance from Twelve-mile Bayou to Red River, measured on line of dam, is 4,500 feet. As the proposed structure would occupy 1,000 feet, this would give 3,500 feet for high-water-way.

The banks of Red River are 6 feet higher than Twelve-mile Bayou. This would give an area of some 18,000 square feet before Red River would be called upon to assist in carrying flood.

The object in leaving this water-way is to afford protection, during a flood, to the

structure, by allowing the water to escape and back up in the rear of the dam and form a cushion to receive the overflow and prevent undermining.

During high-water the whole country is submerged, and there is but little current. This, together with the fact that the proposed outlet is heavily timbered with oak, gum, cypress, &c., indicates that no danger may be apprehended that a new channel would be formed between the end of the dam and Red River.

The difference of level between Twelve-mile Bayou and Red River, on section L, N, March 6, 1874, was 0.07 of a foot, and the fall from site of dam to mouth of Twelve-mile Bayou, March 7, 1874, was 3.06 feet.

The distance by Red River from proposed cut to mouth of Twelve-mile Bayou is 9.66 miles, while from dam to same point is but 3.64 miles. This would lengthen the water-slope over two and one-half times what it now is, with the same fall. The elevation of the banks of Twelve-mile Bayou is 30.90, and when bank-full would give 10 feet on the flats. As the dam would cut off the escape of water by Cross Lake and Twelve-mile Bayou, the only outlet during a good boating-stage would be by Red River, and we would then have all of the lakes as a reservoir for slack-water navigation.

The estimates on this plan were not completed, as, by your directions, the location was changed to Albany Point.

The site on which estimates were made is a line running from Albany Point to Gold Point, on Red River, taking advantage of Islands Nos. 1 and 2.

The crest of the dam is, at an elevation of 42.98 feet, (above zero of gauge at Shreveport,) 2 feet above high-water of 1866 at Albany Point. This elevation is carried 1,000 feet inland from north shore of Sodo Lake, at which point it falls 0.53 per 100 feet for a distance of 1,500 feet, when it reaches an elevation of 34.98, at which it is carried a distance of 3,100 feet, where it reaches the slopes of Red River bank. Total length of dam, 10,400.

The proposed cut is shown by red line from Blind Bayou to Red River. For a portion of the way Blind Bayou would be used; very little improvement would be needed, and would consist in dredging and removing stumps.

The main cut would be through red clay and sand, and is susceptible of easy handling.

The benefits to be derived from this plan are as shown by Leavenworth's section: Red River is 3.80 feet above Sodo Lake; the elevation of the low portion of the dam is 34.98; this would give 14 feet on the flats before allowing any water to escape.

The fall from Jefferson to Albany Point, as stated in Lieutenant Woodruff's report, is but 3.50 feet; this would give over 10 feet of water to Jefferson.

The distance by Red River, from Gold Point, to mouth of Twelve-mile Bayou, is nearly twice as great as by Sodo Lake and Twelve-mile Bayou. This increased distance with difference of level will no doubt materially lengthen the boating-season, and, in my opinion, secure navigation to Jefferson when Red River is navigable to Shreveport.

The following statistics were kindly prepared by Messrs. Johnson & Eberstadt, of Jefferson, Texas, and to whom I am indebted for much valuable information.

While in Jefferson I paid a visit to Kelly's foundry and iron-works, and examined the ore and castings made from it, and can safely vouch for the statements made by Mr. Kelly.

I remain, very respectfully, your obedient servant,

H. A. LEAVITT, C. E.

Capt. C. W. HOWELL,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

We ask, in behalf of the citizens of Jefferson and adjacent country, to lay before you the following facts and statistics, showing the importance of Government aid for the benefit of navigation through the bayou and chain of lakes between the cities of Jefferson, Texas, and Shreveport, La., a distance of ninety-five miles.

For several years, just after the close of the war, there were shipped annually through this channel to New Orleans from sixty to seventy-five thousand bales of cotton, at a freight-cost of from \$1 to \$2.50 per bale; besides large numbers of beef-cattle, large quantities of hides and other productions, and articles of commerce.

In 1869 the number of bales of cotton reached 75,352; hides, 160,000; and all other classes of products in like ratio. During the same commercial year the number of packages of merchandise landed here for the interior reached over 350,000, valued at \$1,750,000, while the value of merchandise received by the merchants of Jefferson was \$20,000,000. At that time the population of the city was 11,000 souls, and business of every class was prosperous in the extreme.

Since that time, from various causes, trade and commerce have been gradually diminishing, and principal among these causes has been the lessening of our navigation,

arising from the expenditure of Government appropriations on the Upper Red River in and about the great raft.

We may here also beg leave to say, and call attention to the fact, that the cutting out of this raft and the turning loose of so great a volume of water, is proving very detrimental to farming-interests on Red River below Shreveport; while, we are assured by our oldest and most competent steamboat-men that but little, if any, good will result from the work to the upper-river navigation.

Whether this be fact or not we are not positively prepared to declare; but, if so, we hope that some clause may be found in the Constitution that prevents the interference of the General Government in benefiting one section of the country and people at the expense and ruin of another.

But should Congress grant the appropriation of \$300,000 now asked for, for the permanent improvement of the lake-navigation in either of the feasible ways that have been suggested by engineers, it will settle all existing difficulties, and benefit a larger population and more territory than any appropriation of the same amount ever made by Congress.

To prove this statement we offer the following facts, together with the agricultural statistics of the territory immediately surrounding and entirely dependent on this outlet for its exports and imports, leaving out many counties even more populous and with larger productions than most of those named. These statistics, too, are from the census of 1870, the latest at command, since which time the population and products have increased 40 per cent.

County.	Cotton-bales.	Live-stock.	Farm-products.	Cash-value of farms.	Improved land.	Unimproved.
	Number.	Value.	Value.		Acres.	Acres.
Bowie	2,990	\$126,295	\$331,261	\$223,347	18,360	108,587
Cass	5,966	255,723	1,066,633	406,566	53,903	182,001
Titus	7,039	467,387	899,135	1,133,072	53,012	297,536
Upshur	7,362	370,570	928,687	590,238	63,804	228,921
Marion	2,862	85,117	126,025	412,591	27,819	87,944
Hopkins	5,417	568,393	874,987	1,037,789	42,371	192,965
Hunt	4,272	779,394	735,109	780,140	41,065	194,442
Total	35,908	2,652,879	4,961,837	4,583,740	300,334	1,302,416

It will be seen that we have only given statistics of seven counties, leaving out more than that number whose interests will always lead them to seek cheap water-transportation for their shipping when it can be reached. The return, however, from the territory given shows how strong are the claims we bring before Congress for a sufficient appropriation. It sums up as follows:

Bales cotton	35,908
Live-stock, value	\$2,652,879
Farm-value	\$4,583,740
Farm-products, (value)	\$4,961,837
Improved land, (acres)	300,334
Unimproved land, (acres)	1,302,416

In this must be added 40 per cent. in increase of production and value of farms and live-stock since 1870.

With permanent navigation, it is safe to declare that 150,000 bales of cotton (to say nothing of the immense numbers of cattle, hides, and various other articles) would be annually shipped through this channel, with a rapid yearly increase, at a saving of 75 cents a bale less than railroad freights, with a like saving in freight on all importations, both to individuals and the General Government, on the large quantities of supplies for the forts and stations west of this, to all of which this is the nearest inland water-navigation.

The Government in many cases has given \$30,000 per mile to railroads, which, for the distance of this stream, ninety-five miles, would amount to \$2,850,000, where we only ask for \$300,000 to insure permanent and uninterrupted navigation that would afford more tonnage and accommodate more commerce than a dozen single-track railroads. And this navigation lasts forever without repairs.

We now reach probably the most important and obvious reason among the many why this improvement should be made; this is to be found in the exhaustless fields of iron-ore and forests of valuable timber by which these lakes are surrounded, all of which are required at less-favored points, and the citizens of which the improvement

of navigation asked for would greatly benefit in the saving by reduced freights, thus proving that the appropriation would be far from a sectional matter.

It is now fully and justly admitted that our iron is the best in the United States, and the quantity inexhaustible. The stock-company, just formed for that purpose, are largely increasing the operations of Kelly's foundry and furnaces, have orders for thousands of tons already—500 tons from one manufacturer alone in Galveston—and the only drawback is the high tariff of railway-freights, which would be overcome by the improvement in question, and thus save thousands of dollars annually, not to the manufacturer, but to the consumer, which class is composed mostly of farmers and laborers, that class which honest legislation should always endeavor to legally protect.

The manufacturer and merchant have their regular profits, and, therefore, all exorbitant freight and other charges always fall on the consumer.

In conclusion, we ask the candid consideration of all to the undoubted early great future of the rich and rapidly growing country by which we are surrounded. A soil unsurpassed in productiveness, a stock-raising region unequaled elsewhere, and a climate healthy and salubrious, with a territory larger than the entire State of New York, and capable of sustaining a more dense population, what can prevent its speedy development to a thriving, populous, agricultural, and manufacturing region?

The demand of commerce will be great, and to meet the wants and requirements of the whole people we ask for this mite from the national Treasury to give us a safe and permanent water-navigation. For the foregoing reasons we ask and demand the relief sought for as a matter of simple justice to a large section of the country and a large population, and for all of which we will ever pray.

E. EBERSTADT.

No estimate has yet been submitted for the cost of completing the work of improvement in Cypress Bayou proper.

The following is the original estimate for the work of one year, at removing stumps, &c., from the bayou, and opening a new route into the lake:

Cost of flat and machinery	\$5,000
Running expenses one year	12,000
Opening new route	3,000
	20,000

The following is the estimate for dredging:

Running expenses six months	\$12,000
Making it for one year	24,000
Making a total estimate for one year's work	44,000

The actual expense for two years has been \$35,573.96.

The balance of appropriation available is expected to complete the work.

My present estimate for cost of work at Albany Point is made greater than that submitted in my letter of May 1, 1874, by the addition of ballast in the construction of the dam, an addition which, if not positively necessary, is certainly prudent.

Whole amount appropriated since commencement	\$60,000 00
Amount expended since commencement	35,573 96

The work is situated in the collection-district of New Orleans, and there is no light-house near it.

I am unable to state if it may effect permanent improvement or not.

Financial statement.

Balance in Treasury of United States July 1, 1873	\$38,000 00
Amount in hands of officer and subject to his check	14,794 38
Amount expended during fiscal year ending June 30, 1874	23,368 34
Amount available July 1, 1874	24,426 04
Amount required fiscal year ending June 30, 1876	372,590 00

The following charts are submitted:

- A. Reduction of Woodruff's chart.
- B. Leavitt's chart.
- C. Plan of dam No. 3, Albany Point.
- D. Plan of dam No. 1, Albany Point.

R 5.

IMPROVEMENT OF CALCASIEU PASS, IN THE STATE OF LOUISIANA.

This work was authorized by act of Congress approved June 10, 1872, and appropriating \$15,000. It was commenced in May, 1873, and continued to June 30, 1873, as reported page 634, Report of the Chief of Engineers for 1873. It was afterward continued and completed January 14, 1874.

There has resulted from the work a straight channel, 60 feet wide and $6\frac{1}{2}$ feet deep, at mean low-tide, from the deep water in Calcasieu Pass to the deep water in Calcasieu Lake; as shown by the accompanying tracing. Vessels drawing $6\frac{1}{2}$ feet loaded have now free access from the Gulf to and from the important lumbering-region about the head of Calcasieu Lake, whereas, before improvement, the route was only open to vessels drawing more than $3\frac{1}{2}$ feet, by lightering over the bar improved.

Since completion of the work, a period of nearly six months, no material filling of the channel excavated has been observed.

The benefit accruing from the work cannot be stated definitely; the following information in that regard is all I have been able to obtain.

A larger class of vessels has engaged in the trade of Calcasieu Pass, since its improvement, without resort to lightering. These have been able to make three trips in the time before required for two trips.

A direct trade with Mexican ports has been started.

The freights on lumber to Galveston and adjacent ports have been decreased \$2 per M.

In Galveston the price of first-quality lumber has been reduced from \$6 to \$7 per M.

By the old system of lightering over Calcasien Bar, what was first-quality lumber at the mills became filled with grit and reached market deteriorated in value, which is not the case now.

I have nothing further to present in the shape of commercial statistics than those contained in my report of 1871.

The work is located at the outlet of Calcasieu Lake, Louisiana, in the collection-district of Galveston, Texas. The nearest light-house is at the Gulf entrance of Calcasieu Pass.

Financial statement.

Amount in hands of officer and subject to his check.....	\$9,287 51
Amount expended during fiscal year ending June 30, 1874.....	9,210 96
Amount available July 1, 1874.....	76 55
Statement of original estimated cost of the work.....	15,000 00
Whole amount appropriated.....	15,000 00
Whole amount expended.....	14,923 45

R 6.

IMPROVEMENT OF THE HARBOR OF GALVESTON, TEXAS.

During the year, operations were confined to the care of property belonging to the work, there being no appropriation available until late in June, 1874, for continuing the work. During the present year, the available appropriation of \$60,000 will be expended in accordance with the recommendation of the board of engineers convened to consider the plan of improvement submitted in my report of December 30, 1873. (Ex. Doc. No. 136, H. of R., 43d Cong., 1st sess.)

The operations possible with the amount of money appropriated look only to a test of the merits of the plan submitted; and it is hoped their results may be presented early in December, when estimates for next year will be forwarded.

The work is located in the collection-district of Galveston, near the light-house on Bolivar Point.

Financial statement.

Amount in hands of officer and subject to his check	\$3,608 31
Amount appropriated by act approved June 23, 1874	60,000 00
Amount expended during fiscal year ending June 30, 1874	3,606 54
Amount available July 1, 1874	60,001 77
Total amount appropriated since June, 1869	137,000 00
Total expended since June, 1869	76,998 23

R 7.

SURVEY AND IMPROVEMENT OF GALVESTON HARBOR AND ENTRANCE,
TEXAS.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., December 30, 1873.

GENERAL: I have the honor to transmit the following report on the recent survey of Galveston Harbor and entrance:

Charts and statistics are transmitted as follows:

- 1st. Chart of survey.
- 2d. Tracing from chart of survey of 1852 and 1867.
- 3d. General chart, to show location of dam M. N.
- 4th. Diagram of tide observations.
- 5th. Record of wind observations.
- 6th. Sections showing plane of blue clay, with strata above.
- 7th. Details of cement-covered gabions.

Very respectfully, your obedient servant,

C. W. HOWELL,
Captain of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

THE SURVEY.

The survey carried on in connection with the work of improvement of Galveston Harbor was made in accordance with recommendation contained in a previous report from this office, for the purpose and substantially in the manner there indicated, the purpose being to furnish data for a general plan designed for the improvement of the harbor, for obtaining 18 feet of water over both the inner and outer bars, and for forming estimates of the probable cost of same.

The facts collected are displayed on the charts herewith, and in the reports of assistants, made a portion of this report.

Lieut. H. M. Adams, Corps of Engineers, U. S. A., in charge, reports as follows:

GALVESTON, TEX., *June 19, 1873.*

SIR: In compliance with your order of September 9, 1872, I have to report on the survey of Galveston Harbor as follows:

The object of the survey, as stated in your letter of instructions, was "to determine

and estimate the cost of some plan calculated to give an eighteen-foot entrance to Galveston Harbor."

We have made a complete hydrographic survey of the outer and inner bars of the Bolivar and Galveston Channels and of the city wharf-front. The chart also includes Bolivar Point, Fort Point, Pelican Spit, and the end of Pelican Island. This work is plotted on a scale of 70000.

To determine the character of the material to be removed in order to give the required depth of channel, and also to determine the nature of the foundation available for the construction of jetties or breakwaters, borings have been made at different points (shown on the chart) to a depth, in one case, of 81 feet below mean low-water.

A tide-gauge was established, the zero of which was referred to a fixed bench, and half-hourly readings have been taken since the commencement of the survey. From the United States signal-observer at this station we have obtained the record of the direction and force of the wind for the same period. This record of tide and wind has been plotted on section paper. (Sheet D.)

Many observations have been made at the stations indicated on the chart to determine the direction and velocity of the different currents, particularly on the outer and inner bars.

Careful attention has been paid to the subject of littoral currents, and the results of the observations are indicated in exact position on the chart.

The survey was commenced October 1, 1872, and the field-work was continued until April, 1873; when, unable to work out-doors on account of fogs, northers, or other bad weather, the time was occupied in plotting field-notes in the office.

An effort was made to connect this survey with the Coast-Survey work by determining the position of their plane of reference, but after some correspondence with Mr. J. E. Hilgard, assistant in charge of the United States Coast-Survey Office, to ascertain the location of their bench-mark, an examination was made which proved that the bench-mark left by the Coast-Survey party had been washed away.

We have been able to continue our tidal observations over a period of eight months, which gives a very close approximation to the height of mean low-water. The chart of the survey A, submitted herewith, is shaded so as to show at a glance the position and extent of the outer and inner bars. The depth of water on the outer bar is 12 feet. The distance from 18 feet to 18 feet depth, across this bar, is 7,040 feet.

The position of the bar is much exposed, and the directions of the currents, both flood and ebb, are very much dependent on the direction and force of the wind. The bar is composed of fine rounded sand and very fine broken shell. This material shifts about with every tide and current, so that the channel is constantly changing.

On the inner bar we found an intricate channel, to the north of the middle ground, giving 12 feet of water. The distance across this bar, from 18 feet to 18 feet depth, is 5,000 feet. The inner bar is not so much exposed as the outer bar; but the bottom is composed of the same materials, and the currents are quite as variable as on the outer bar.

A pile-jetty was commenced by the city of Galveston, at Fort Point, in 1869, with a view to deepening the channel across the inner bar. This work has been continued since 1869, and is now over a mile in length. The effect of it has been to deepen the water along the front of the jetty, but a circular bar has been formed beyond the outer end of the latter, and a large middle ground still remains opposite the outer end of the structure. There is now, however, a channel 2 feet deeper than that indicated by the chart of 1867. The middle ground on this bar seems to be formed by an eddy. We have noticed that when the tide is running in at station E (see chart) it may be commencing to ebb at station A. (The directions of the flood and ebb currents are indicated, on the chart, by the blue and red arrows, respectively.) By examination it will be seen that a large eddy is thus formed, which may account for the existence of the shoal water, which we have called the middle ground on the inner bar.

In order to compare the survey of 1867 with the results which we have obtained, a tracing sheet, B, enlarged to 70000, has been made from the chart of 1867. This may be placed over the chart of 1873, and the changes which have taken place can be noted at once. On the outer bar we see that the ship-channel has shifted some distance to the southwest; that the depth of water in this channel has slightly increased, and that the distance across the bar from 12' to 12' depth has diminished. The changes are, however, unimportant, since the sand of which the bar is composed shifts about so much that a year hence we may find the channel in still another place, with a trifle more or less water in it.

We have already indicated the change which has taken place on the inner bar. This has been accompanied by a continuation of the movement of Pelican Spit toward Pelican Island, which was noticed in 1867. The Gulf has encroached 300 feet on the east side of Fort Point, but the extremity of Galveston Island is in about the same place as in 1867. It has been stated, however, by the board of harbor improvement that the point has made in a direction toward Bolivar since the commencement of the jetty in 1869.

CURRENTS.

We have indicated on the chart at various points the direction of the current by arrows—blue for flood-tide and red for ebb-tide. The depths at which the observations were made are indicated thus: d —depth, in feet. The velocity in miles, per hour, is indicated by V . The direction and force of the wind is also given for each observation. By examining the notes at velocity stations W and Y , we see that the flood-tide current in the main channel over the outer bar does not run in the direction of the axis of the channel, but rather across the channel. This is an objection against any attempt to improve this channel in preference to the "cylinder channel," where the currents, both flood and ebb, appear to run in the direction of the deepest water. See velocity stations S and T .

By careful and repeated observations for a littoral current outside of the outer bar, we have determined, beyond a doubt, that this current depends entirely on the wind. We have found it setting in both directions along the coast, but generally with the wind at the time of the observation. During a calm, after a southeasterly wind, we found the current setting up the coast toward Sabine. See velocity stations $k', l', m', n', q', r', o',$ and p' , on reduced chart on main sheet.

Three observations were made on different days, when we found it impossible to discover any littoral current whatever. The greatest velocity of the littoral current observed was one-half a mile per hour.

BORINGS.

For making the borings we used a $2\frac{1}{2}$ " gas-pipe, jointed in sections of $6'$; a $\frac{1}{4}$ " pipe, also jointed, was used for the auger-shaft inside the main pipe. The large pipe was fitted with a steel point at the lower end, which was fastened by means of a reducer, so that it could be attached or removed from the inside of the pipe by means of the auger-shaft. In boring through clay the point was inserted, and the large pipe forced down by means of a small pile-driver. The point could be withdrawn at any time, and a specimen of the earth brought up with a pod-auger. In quicksand the small pipe was inserted without the steel point, and a force-pump connected with the top of it. By forcing water down the center pipe the quicksand was made to rise in the outer pipe and run over at the top. Borings were made in this manner to a depth of 70 feet, in quicksand, without any difficulty. Several attempts were made to bore on the outer bar by using a large dump-flat, anchored for the purpose, but we found it impossible to succeed on account of rough water. We were finally obliged to build a scaffold to stand on the bottom, and large enough to support the boring party with their tools.

The following table gives the result of the boring operations. The locality of each boring is given by the corresponding number on the chart:

- No. 1 is at Fort Point.
- No. 2 is at Fort Point.
- No. 3 is at Fort Point.
- No. 4 is on Pelican Spit.
- No. 5 is on Pelican Spit.
- No. 6 is on the outer bar.
- No. 7 is on Bolivar Point.
- No. 8 is on the outer bar.

*Borings.**Water-surface.*

	I.	III.	IV.	V.	VI.	VII.	VIII.
Water, 4.	Water, 5.	Water, 14.	Fine sand and pulverized shells, 6.	Fine sand and pulverized shells, 7.	Water, 11.	Fine sand and pulverized shells, 11.	Water, 11.
Fine sand, pulverized shells, and finely-broken shells mixed, 34.	Fine sand and pulverized shells mixed with clay, 49.	Hard fine sand and pulverized shells, 21.	Clay, with a large am't of fine sand and pulverized shells mixed, 18.	Fine sand and pulverized shells, with a small amount of clay mixed, 27.	Fine sand and pulverized shells, 20.	Clay and fine sand, few broken shells, 15.	Fine sand and pulverized shells, 60.
Same as last with a small am't of clay, 39.	Clay, with small am't of fine sand and pulverized shells, 57.	Very fine sand and pulverized shells with a small am't of clay, 39.	Fine sand & fine broken shells, 28.			Clay and fine sand and pulverized shells mixed, 22.	Clay, with fine sand and pulverized shells, 64.
Clay, with small am't of pulverized shells and fine sand, 44.	Fine sand and pulverized shells, with a few fine broken shells, 72.	Same as last with few broken shells, 46.	Fine sand and pulverized shells with small amount of clay, 35.			Very fine sand and pulverized shells, 27.	
Clay, with a very small am't of fine sand and pulverized shells, —.	Clay, with a trace of pulverized shells, 81.	Clay, with small am't of fine sand and pulverized shells, 55.	Clay, with large am't of fine sand and pulverized shells, 43.			Shells, with few fine broken shells and some clay, 32.	
						Fine sand and pulverized shells, 45.	
						Clay, fine sand, and fine broken shells mixed, 50.	
						Fine sand and pulverized shells, trace of clay, 54.	
						Clay and pulverized shells, few fine broken shells, 58.	
						Gas escaped, 59.	
						Clay, least trace of pulverized shells, 62.	

NOTE.—The Roman numbers correspond to similar numbers in red on the chart, which indicate the positions of the borings. The depths of the borings are measured from the water's surface of mean low-tide.

The borings show that the outer bar is composed principally of quicksand to a depth of 60 feet below the surface of the water.

The borings at Fort Point and Pelican Spit, together with other borings made to a less depth from a boat on the inner bar, show that this bar is composed of the same material to a depth of at least 39' below the surface of the water.

DEMAND FOR THE PROPOSED IMPROVEMENT.

The following statistics, compiled from the records of the custom-house at Galveson, show a very rapid increase in the trade of this port during the five years from 1867 to 1871, inclusive:

Year ending—	Imports.	Exports.	Duties collected.
June 30, 1867	\$461,986	\$6,987,396	\$297,812
June 30, 1868	586,334	6,067,660	253,599
June 30, 1869	955,783	9,615,716	184,177
June 30, 1870	509,231	14,869,601	268,477
June 30, 1871	1,255,003	13,764,341	611,333

The following letter from Mr. N. Patten, collector at Galveston, gives a good idea of the amount of business transacted at this place during 1871 and 1872:

CUSTOM-HOUSE, GALVESTON, TEX.,
Collector's Office, February 3, 1873.

SIR: I take pleasure in rendering the information you solicit in your communication of the 30th ultimo, relative to the commerce of this port.

In answer to your interrogatories I submit the following:

1st. Number of entrances of steam, 1871	277
Number of entrances of steam, 1872	252
2d. Tonnage of same, 1871	293, 116
Tonnage of same, 1872	395, 755
3d. Clearances—steam, 1871	283
Clearances—steam, 1872	252
4th. Tonnage of same, 1871	303, 473
Tonnage of same, 1872	276, 444
5th. Entrances—sail, 1871	359
Entrances—sail, 1872	330
6th. Tonnage of same, 1871	135, 255
Tonnage of same, 1872	115, 350
7th. Clearances—sail, 1871	450
Clearances—sail, 1872	345
8th. Tonnage of same, 1871	132, 898
Tonnage of same, 1872	119, 457
9th. Total value of imports dutiable, 1871	\$1, 536, 094
Total value of imports dutiable, 1872	1, 802, 535
10th. Total value of imports free, 1871	314
Total value of imports free, 1872	311, 221
11th. Total value of exports, 1871	16, 157, 584
Total value of exports, 1872	12, 056, 570
12th. Duties collected on imports, 1871	693, 521 74
Duties collected on imports, 1872	622, 934 24

I remain, sir, very respectfully,

NATHAN PATTEN,
Collector.

H. M. ADAMS,
Lieutenant of Engineers, U. S. A., Galveston, Tex.

I have been assisted in the survey of Galveston Harbor by Mr. H. C. Ripley. His report forms a part of the record of our work, and is forwarded herewith.

Very respectfully, your obedient servant,

H. M. ADAMS,
Lieutenant of Engineers, U. S. A.

C. W. HOWELL,
Captain of Engineers, U. S. A.

H. C. Ripley, assistant engineer, reports to Lieutenant Adams, in regard to the conduct of the survey, as follows:

GALVESTON, TEX., June 23, 1873.

DEAR SIR: I have the honor to make the following report on the survey of Galveston Harbor and entrance, Texas.

The field-work was commenced October 7, 1872, and conducted on the same general plan as that adopted for the United States Coast Survey.

The triangulations were made with a transit manufactured by W. & S. E. Gurley, Troy, N. Y., and since it was the cause of some delay and dissatisfaction, a brief statement of some of its peculiarities may not appear out of place.

The telescope has not sufficient power to discover an object the size of a man at a distance of more than about three miles, in the clearest weather, and consequently it was exceedingly difficult to see my stations, or to locate buoys and beacons, some of which were at a distance of four and five miles. This was a source of considerable delay, but the great source of error is in the graduation of the horizontal limb. Each angle was repeated from three to five times, and although the instrument is graduated to read to single minutes, a difference as great as two minutes has been observed in the same angle read from different parts of the limb. However, the country being open and level, I have been able to check the work in so many ways that the mean result for the position of any station does not differ from the extreme limit, in cases of greatest discrepancy, by more than three feet, and consequently, in so small a survey, will

not affect the accuracy of the chart. But this is sufficient to show that in a survey of any extent such an instrument would be entirely inadequate for the purpose.

Between the stations located by triangulation, transit lines were run to compute the topography. In this case the instrument being invariably set up on the reverse of the last reading taken, the error of graduation did not show itself and the result attained was remarkably good; the greatest error in azimuth in joining any two stations was three minutes, in a distance of two and one-half miles. The principal source of delay in the triangulation was due to foggy weather, but most of the time was utilized taking topography.

The hydrography was commenced as soon as the stations were built. For this purpose there was at my disposal the tug "Hall," which was used for outside soundings, and a small four-oared boat for inside and shallow soundings. I was able to utilize much of the windy weather by sounding outside when the wind blew off shore and inside when it blew from the Gulf. The only drawback to this admirable arrangement was the exceeding difficulty in preventing the "Hall" from getting aground. She draws seven and one-half feet of water, and since at low-tide in many places on the bar there is less than this depth of water, and there have been many changes since the last coast-survey chart was made, it was impossible to keep her from grounding occasionally if she ventured from the regular channel. This being true in still water, the least swell increased the depth of safety and a large swell made it dangerous to cross the bar, even in one of the channels. It was in this way that she broke her stern-post, November 30, passing out the "cylinder channel" in nine and one-half feet of water and scarcely any wind, and was thus disabled for further use until the soundings were finished. The "Hall" being withdrawn for repairs, the "Rattler," a sloop of five tons, drawing about three feet of water, was chartered, with which the outside work was completed. This answered the purpose very well; but a larger one, and drawing no more water, would have been preferred. However, we were able, with a moderate breeze off shore, to do more work with her than with the "Hall," and at much less expense.

The soundings were taken with a pole, to the depth of ten feet, and given in feet and tenths. At greater depths they were taken with a line, with ten-pound lead, and given in feet and half-feet.

The character of the bottom was given and recorded at every change in its nature. The locations were made from the boat by means of two sextants, with objects on shore, the position of the boat being located every two to five minutes. The soundings were taken as often as the leadman could conveniently heave the lead, averaging about four soundings per minute, in twelve feet of water.

The difficulty of locating was the great source of embarrassment in the entire survey, and was occasioned by the almost constant prevalence of fog. The tripod stations were entirely useless, except in the clearest weather, or when near them; and although all prominent objects, such as light-houses, beacons, buoys, wrecks, church-spires, &c., were located and used, yet the condition of the atmosphere was such, much of the time, that it was difficult at a distance of four or five miles to distinguish one object from another, even if it could be seen at all.

When the wind was blowing, especially from the north or west, it was generally clear, but as soon as it became calm enough for sounding, a fog was most certain to rise. Almost the only exception to this was immediately following a fierce "norther," when one or, perhaps, two days would be clear and fair.

The soundings were commenced November 4, 1872, and continued during favorable weather, until completed, January 24, 1873.

The following is the statement of the time actually employed taking them :

	Hours.	Minutes.
In November	68	45
In December	66	49
In January	46	36
Total	182	10

At seven hours per day, an average day's work, this gives 26 days.

The whole number of days is 81, giving a ratio of 1 to 31 as the time favorable for this kind of work. The whole number of soundings taken is 30,000; but with the scale adopted for the chart only about one-fourth of this number, or 7,500, were plotted. The hydrographic area embraced in the survey is about 42 square miles. This gives an average of 714 soundings per square mile, and 161 square miles of hydrography completed per day. A tide-gauge was kept from the beginning of the survey and the reading recorded every half hour, day and night. It was located at the eastern end of the city, as being the most available point convenient of access. It would have been desirable to have had one on the outer bar, but this was impracticable in the absence of a self-registering gauge. As the nearest approach to the outer bar, a second

gauge was kept at Fort Point for a period of twenty days, by means of which a ratio was established between it and the one in the city. By means of this ratio, the outside soundings were reduced, and the almost universal agreement in them, where lines of soundings crossed each other, proves the result not unsatisfactory.

CURRENTS.

The current observations were commenced as soon as the soundings were completed. For this purpose a keg, weighted with lead to make it sink, and suspended with a small cord to a tin float just sufficient to buoy it up, was arranged. The cord could be made of any desirable length, and, since the float was small compared with the keg, the velocity of the float would be very approximately that of the current at the depth determined by the length of the cord. To measure the velocity, a log-line was attached to the float, and the time occupied in running out any known distance was noted. The direction of the float was taken with a mariner's compass; at the same time the bearing of one or more known objects was taken to test the accuracy of the compass, the boat being anchored and its position located. Observations were taken at the surface, mid-depth, and bottom, and repeated three or more times. For these observations such days and stages of the tide were selected as should give the greatest velocities.

CONCLUSIONS.

The swiftest currents occur when the moon's declination is large, and during the last quarter of the ebb and the first quarter of flood tide. They are also influenced by wind.

The tide begins to flood in Bolivar Channel some time before it ceases to ebb in Galveston Channel. It also flows along the flats and margins of Galveston Channel before it has ceased ebbing in the center. At the outer end of the breakwater at Fort Point when the flood first sets in, it flows directly across the channel to the west, and, meeting the ebb-tide, forms a partial eddy, which is doubtless the cause of the middle ground or shoal place on the inner bar.

At certain stages of the tide the water flows between Pelican Island and Pelican Spit in the direction indicated by the arrow, the velocity varying greatly at different times; but it has never been observed to run in the contrary direction. It is possible that this contributes to the formation south of Pelican Spit.

The tide at the gauge begins to rise generally from one to three hours before flood sets in.

The littoral current does not seem to be affected by the tide, but runs in one direction for days at a time, and then will change and take the opposite direction or cease to run altogether, depending apparently upon the direction and force of the wind. It, however, has its effect on the tide, influencing the direction at which it crosses the outer bar. Thus, when there is no littoral current and the tide flood, it crosses the bar normal, or nearly so, to the direction of the bar itself; but when the littoral current is running to the northeast the direction of the tide will be deflected from the normal to the north; when it is running to the southwest it will be deflected to the south, and in a degree corresponding to the velocity of the littoral current and the force of the tide. The same is true at ebb-tide, but perhaps not to so great an extent.

To show the uncertainty of this littoral current, it is worthy of note that three observations, on different days, were taken beyond the influence of the tide, when it was impossible to discover any current whatever. At other times it has a velocity of one-half mile per hour, and perhaps greater. This, however, is the greatest velocity observed.

THE CHART.

The plotting was continued during unfavorable weather for field or hydrographic work until they were completed, and then it was continued with slight interruptions until finished. The principal stations and some of the more prominent objects used for locating soundings were plotted by co-ordinates. The secondary stations, used in topography and minor objects, were plotted by intersection. The shore-line is that of mean low-tide, as near as could be produced by means of the tide-gauge and the location of high-water of the day and the water's edge at the time.

Many of the current observations were not plotted, since only those showing an appreciable velocity were considered of any value.

Very respectfully, your obedient servant,

H. C. RIPLEY.
Assistant Engineer.

Lieut. H. M. ADAMS,
Corps of Engineers, U. S. A.

From the facts established by this survey, and by previous surveys officially reported to the Chief of Engineers, the following may be gathered and presented as important in considering plans of improvement:

PLAN OF HARBOR ENTRANCE AND BAYS.

The Gulf coast, from Calcasieu River past Galveston to Aransas Pass, has a trend nearly northeast and southwest. Galveston entrance is a little east of the center of this stretch. Entering Galveston Harbor from the Gulf we first meet with what is known as the outer bar, stretching in a semicircle from Bolivar Peninsula on the east to Galveston Island on the west, across the entrance to Galveston Bay, and affording over its crest only a depth of 12 feet of water, a depth but slightly exceeded or decreased within the time covered by reliable record. Passing this bar we enter the wide, deep tide-bore known as Bolivar Channel, affording a depth of 40 feet, separating Bolivar Peninsula from Galveston Island, and, after passing both, branching out into the shallow water of Galveston Bay, which latter, with its east and west bays, affords a water area of 455.12 square miles, daily served by the Gulf tides through Bolivar Channel.

Opposite the head of Bolivar Peninsula a branch of Bolivar Channel, leaving at right angles to the latter, runs along the curving inner face of Galveston Island, forms Galveston Harbor, and loses its depth in the shoal water toward West Bay.

Obstructing this branch, and opposite the head of Galveston Island, is what is known as the inner bar. Separating this branch from the other branches of Bolivar Channel is a large middle ground, of which Pelican Spit and Pelican Island are the only portions out of water.

The fresh-water streams of any size discharging into the bay are the Trinity and San Jacinto. These debouch at the head of the main bay, thirty statute miles from the outer bar. Their mouths are obstructed by bars formed of the grosser deposits brought down by their currents, and about midway of Galveston Bay the lighter deposit is arrested by Redfish Bar, extending entirely across the bay. There is no indication of river deposit having reached the outer bar.

CHARACTER OF FORMATION.

The upper stratum of Galveston Island, Bolivar Peninsula, Pelican Spit and Island, and of the bars, is of the fine rounded sand peculiar to the islands forming the cordon littoral of the Gulf coast. It has all the characteristics of a quicksand, is easily moved, when dry, by the wind; the littoral current moves it back and forth along the coast; waves and tidal currents, where it is exposed to their action on the bars, shift it with every change in direction of wind and velocity of current, making frequent changes in the shape of the bars and the channels across them. Vessels grounding on it strike as on a rock; vessels wrecked by the action of the currents induced by their presence gradually sink beneath the surface.

It affords the least desirable of all foundations on which an engineer may be obliged to build.

Its depth increases from the bay outward, with a dip to the eastward, as is best shown by the sections and diagram submitted.

The strata beneath are of sand, shells, and clay in varying proportions, gaining in consistency with depth, the lowest stratum resting on

the stiff blue clay underlying the whole Gulf-coast formation west of the Florida Reefs.

This clay stratum outcrops at Sabine Pass, east of Galveston, and at the mouth of the Brazos River, west of Galveston. From Galveston its dip appears to be to the eastward.

Without borings along the coast, we may venture the supposition that Bolivar Channel is about on a synclinal axis of this stable formation.

The land about the entrance is low and flat.

CHANGES IN SHORE-LINES, BARS, AND CHANNELS.

Comparing the charts submitted herewith (of this survey and of 1850 and 1851) and those of 1867 and 1841, sent to the Chief of Engineers with the report of Gen. M. D. McAlester, made in 1868, marked and continued changes in shore-lines, bars, shoals, and channels will be observed. The following are the most important noted :

SHORE-LINES.

The northeast point of Galveston Island (Fort Point) since 1841 has steadily moved to the westward, since 1851 retaining essentially the same outline; up to 1851 it had moved 700 yards; from that to 1867, 400 yards; from that to the time in 1870 when the movement was checked by the jetty construction then started, it moved 100 yards.

It is now 1,200 yards west of its position of 1841.

On the Gulf side of Galveston Island the movement has tapered to nil at a point opposite Galveston City, and on the harbor side has been confined to the immediate neighborhood of the Point.

This movement was followed by a corresponding advance of Bolivar Point, opposite.

In 1841 Pelican Spit was a shoal to the west of Fort Point. As the movement of Fort Point progressed, this became shoaler and moved westward in proportion to the movement of the Point.

It is not known at what time it appeared above water, but it was some time before 1851. From 1851 to 1867 it moved directly west about 500 yards, retaining its shape and height.

In 1872 it was about 200 yards farther west, had retained its shape at the northern end and greatly widened at the southern. It has moved faster, it will be observed, than Fort Point, thus increasing the distance between the two.

Pelican Island has not materially changed.

CHANGE IN BARS.

The inner bar has been created since 1841, at which time Galveston Harbor and Bolivar Channel were connected by a channel 30 feet deep.

The commencement of the bar was first noted in 1843, from which time until 1867 it shoaled irregularly but persistently to about nine feet, and lengthened in proportion to the movement of Fort Point.

In 1872 works of improvement before referred to had increased the depth to 12 feet.

The outer bar was moved slightly gulfward, and only suffered temporary changes in the depth of water over its crest, which depth is now, as it was in 1841, about 12 feet.

CHANNEL CHANGES—BOLIVAR CHANNEL.

Between headlands this channel has widened slightly and deepened materially; passing outside of the headlands, it branches out to the right and left, thus forming several channels across the bar.

The central channel (known as the Cylinder Channel) crosses the bar directly, and, while affording little less depth than the side channels, apparently has its ebb and flood currents less deflected from the line of its axis by the winds.

Along the shore of Bolivar Peninsula is a swash channel, south of the central channel; and in direction following the line of Galveston Island shore is a wide channel, used by the deepest-draught vessels admitted to the harbor, and, by reason of the slightly greater depth, properly considered the main channel.

Galveston Island was a swash channel similar to that along the face of Bolivar Peninsula.

The changes in these are interesting. For convenience I will refer to them as Nos. 1, 2, 3, and 4, in the order above named.

The axis of No. 1 in 1867 was found north (near Bolivar Peninsula) of its position of 1851; in 1872 it had moved yet farther north.

This movement has been followed by the disappearance of a small islet (Bird Key) on that side, and by the shoaling of No. 2.

No. 3 in the mean time has been shifting its axis in the contrary direction, or nearer Galveston Island, and at the same time it has advanced its 12-foot curve very greatly to the southward. The effect of this move has been the obliteration of No. 4.

The charts of 1851, 1867, and 1872 show these movements to have been continuous between their dates, and yet in progress.

Passing to the head of Bolivar Channel, we find that a similar deflection of the deep-water axis has taken place in an opposite direction, or toward Pelican Island, thus throwing the main channel into Galveston Bay, farther to the west, and extending the branch that heads toward East Bay.

GALVESTON HARBOR.

Between 1851 and 1867 Galveston Harbor shoaled and shortened noticeably at its upper extremity, besides being shortened at its lower by the formation of the inner bar. It also narrowed perceptibly, which was a matter of more importance, considering the little width of the deep-water portion. In 1872 the width was found restored to nearly that of 1851, and the length of deep water about the same.

In Galveston Bay, west and south of Pelican Island, comparison of charts shows appreciable shoaling along the western margin of the bay and at the entrance to West Bay.

That these changes have greatly injured Galveston Harbor is patent, as also is the inference that if they are allowed to continue in the same direction they will ultimately destroy the harbor.

AGENCIES EFFECTING CHANGES.

The Gulf tides and the currents (into Galveston Bay) caused by them having formed Bolivar Channel and Galveston Harbor, if afterward uninfluenced by other causes, would probably not have been the means of effecting changes noted.

The winds have alone been the cause of changes—by the changes

they effect in direction and velocity of currents, and by the littoral current they cause.

The relations between the tides, winds, and their resulting currents are so variable that they are best studied from the chart. Tidal diagram and wind tables submitted, and these are arranged for the purpose of making unnecessary a long written statement.

The following may be useful in directing study and indicating effects:

The highest tide observed during the time covered by our gauge record was $3\frac{3}{16}$ feet above mean low-tide, the lowest $2\frac{1}{16}$ feet below this plane, giving what may be considered as a fair annual range of $6\frac{1}{16}$ feet.

The daily range of the tides is much less, and so variable because of winds that it cannot be stated; the greatest observed was $2\frac{1}{16}$ feet, the least $\frac{1}{16}$ feet.

The prevailing winds are from south around to northeast. Those next in frequency of occurrence are from the north and northwest; those most infrequent are from the west and southwest. (See tables.)

These various winds apparently produce the following effects:

Continued from the southeast and east, they raise the tides in Galveston Bay, making strong floods and weak ebbs.

From north and northwest they deplete the bay, reversing the above.

From northeast they retard the ebb from West Bay after the tide has commenced to flood through Bolivar Channel, thus causing the eddy forming the middle ground on the inner bar.

All winds from the eastward drive the tide currents toward the head of Galveston Island and Pelican Spit, thus moving them continually westward.

Easterly and northeast winds cause a littoral current in the Gulf, carrying drifting sand to the west.

Westerly, south, and southwesterly winds reverse this current and the direction of drift.

The outer bar has been formed by this drift, and its shape given by the ebb and flood currents through Bolivar Channel; all, or nearly all, of the alluvial matter brought down by the streams emptying into the bay being deposited before nearing the bar.

The prevailing winds favor the flood current in filling West Bay around Pelican Island, rather than through Galveston Harbor; the difference in distance by the two routes being only about one mile. The effect of this is to shorten and narrow the harbor.

Winds from the south and southwest drive a large portion of the ebb from West Bay around Pelican Island, decreasing the volume of ebb through Galveston Harbor to the detriment of the channel across the inner bar. Northers, besides being dangerous to shipping in the harbor, bring in deposit from the west part of Galveston Bay.

PLANS FOR IMPROVEMENT.

It is evident from the character of the bar formation, and the exposed position of both bars, that improvement by dredging is not worthy of consideration.

Improvement can only be made by employment of jetties and training-walls.

FOR IMPROVEMENT OF OUTER BAR.

It is proposed to construct parallel jetties along the lines marked C D and E F on the chart. The jetties are to be made of cement-covered

gabions, the details of which are shown by a drawing herewith. The gabions are to be six feet in diameter and six feet high, two rows in each jetty; all to be fastened together by copper wire at the tops, and filled with sand by a dredge-boat alongside as they are placed in position. They may be called submerged jetties since they will not, except on a short portion of their lines, be built up to the plane of mean low-tide, while for the greater part their tops will be five or six feet below that plane.

The present area of discharge over the bar is 411.184 $\frac{2}{5}$ square feet. The contracted area will be 274.112 square feet, the former measured along the crest of the bar, and the latter along the jetties and that portion of the crest between them.

The jetties are expected to act as training-walls for the lower ebb current, while the upper will pass over them. They are calculated to give a depth on the outer bar of between 18 and 19 feet, and at the same time only confine and direct so much of the ebb and flood currents as may be useful, thus preventing as great advance of the bar gulfward as might be expected, were the jetties built up to the plane of mean low tide; further making them less exposed to the destructive action of storms, giving them less weight to sink them into the unstable material offered for a foundation, and making them less expensive.

It is thought these jetties will serve to catch the drifting sand brought by the littoral currents until they are covered by it, and that afterward the sand will be carried over them rather than around their ends, giving a cross-section something like this:

Jetty C D 20,800 feet long.

Jetty E F 16,200 feet long.

Number of gabions 12,333, at \$30..... \$369,990

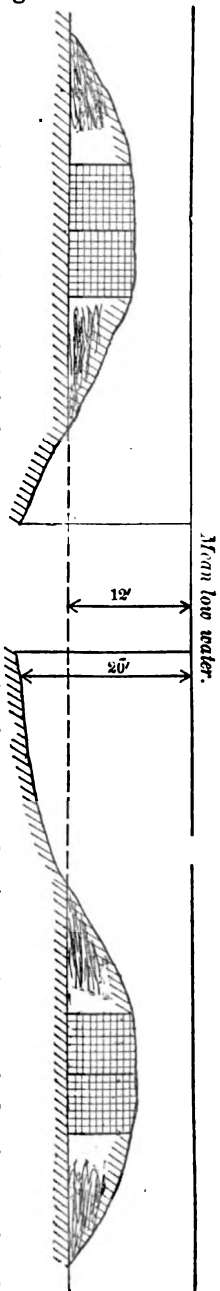
Sand filling 77,483 cubic yards, at 50 cents..... 38,744

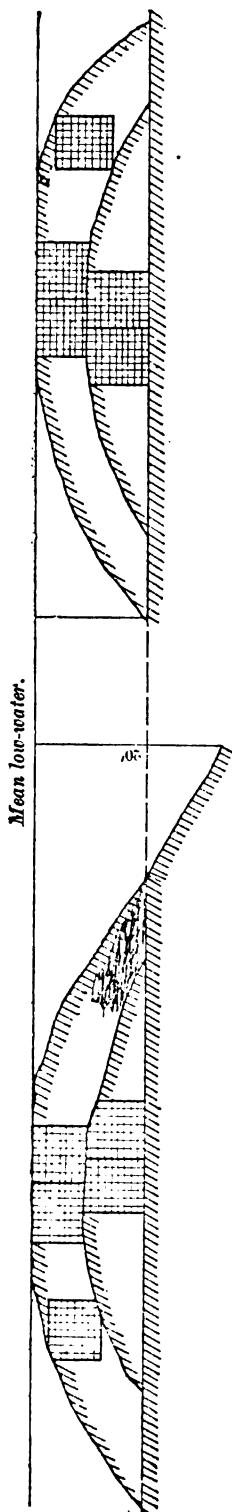
Total cost..... 408,734

The cost of the gabions has been determined by making experimental ones; the cost of the filling was determined from experience in dredging on Red Fish Bar, where the work was as much exposed as it will be on the outer bar.

The two jetties should be built out so that their heads may be kept nearly opposite, for the reason that during the course of construction it may be found that shorter jetties than those laid down may answer all our purposes.

This reason suggests what is true, that this project, and all others for the improvement of the entrance to Galveston Harbor, must involve, while being carried out, modifications of the original plan, either to economize or render the work more effective. For example, it may be found not necessary to carry the jetties to the crest of the bar. In this case they will cost less than the estimate. On the other hand it may be found necessary to raise them. In this case I present the following estimate.





For one row of gabions placed 100 feet from the two rows already placed, and for two rows on top: (See sketch.)

18,499 gabions, at \$30	\$554,970 00
116,229 cubic yards filling, at 50 cents	58,114 50
Total	613,084 50
Previous estimate	403,734 00
Total	1,021,828 50

It is possible that the addition for which the last estimate is made may be found necessary; I do not think it will.

After construction these jetties will, from time to time, require extension to keep pace with extension of the bar gulfward.

The times and amounts of such extensions cannot be stated, but it is my opinion that the advance of the bar will not be rapid.

This is based on the fact that the bar does not receive additions from the bay, but only from the littoral current which drifts the sand along the coast.

IMPROVEMENT OF INNER BAR.

The jetty C D, by extending the head of Galveston Island to the position it had in 1841, when there was 30 feet of water over what is now the bar, will, I think, have the effect of giving at least a 20-foot channel across the bar.

The effect of the short jetty already built to C indicates this.

IMPROVEMENT OF THE HARBOR.

The dams M N and K I, with Pelican Island and Pelican Spit, cut off West Bay from Galveston Bay, and are designed to have the effect of throwing all the water to fill West Bay as far as Caronkaway Point, through Galveston Harbor, for the purpose of widening the harbor. They will also return all of the ebb through the harbor and over the inner bar, resulting in increase of depth of channel across the latter. They will also protect the harbor from northers.

ESTIMATES.

Dam K J, 2,600 feet long. Number of gabions, 4 feet by 4 feet, 650; cubic yards of sand-filling 1,210; 650 gabions, at \$15.80	\$10,370
1,210 cubic yards filling, at 40 cents (by hand)	484

Total

10,75

Dam M N, 20,100 feet long. Number of gabions, 4 feet by 4 feet, 3,600; number of gabions, 6 feet by 6 feet, 950; cubic yards of filling, 12,627:

3,600 gabions, at \$15.80	\$56,880
950 gabions, at \$30	28,500
12,672 cubic yards filling, at 50 cents	6,336

91,716

Grand total cost of dams

102,470

The jetty D H is designed to cut off all the flood-tide that would find its way over the shoal the jetty covers, and to carry the full volume of the tide into the harbor to widen and extend it opposite the city front.

ESTIMATE.

G H, 5,000 feet long; number of gabions, 4 feet by 4 feet, 1,250; cubic yards of sand-filling, 2,282.

1,250 gabions, at \$1,580	\$19,750 00
2,282 cubic yards filling, at 40 cents, (by hand).....	912 80

Total cost.....	20,662 80
-----------------	-----------

After the construction of the jetty G H, it may be found necessary to move the city wharf-front, which is now reached by long causeways, nearer the city. This will be the duty of the wharf company.

It will probably be advisable to connect the jetty C D with the wharves by a cheap levee, closing the break across Galveston Island, between the city and Fort Point, to prevent the water during northers from escaping from the harbor in that direction. Plans and estimates for this work can only be made after ascertaining the effects of the other harbor structures recommended.

SUMMARY OF ESTIMATES.

Jetties C D and E F.....	\$408,734 00
Dams M N and K J.....	102,470 00
Jetty G H	20,662 80
Total	531,866 80
Possible additions to height of jetties C D and E F.....	613,084 50
10 per cent. for contingencies	1,144,951 30
Grand total.....	1,259,446 43

ORDER OF CONSTRUCTION.

1. Jetties C D and E F. Two rows of gabions.
2. If needed, a third row, and two rows in second tier.
3. The dams of K J and M N.
4. The jetty G H.
5. If needed, the protection to harbor-front.

APPROPRIATION RECOMMENDED.

For year ending June 30, 1875, \$500,000.

Much of the work can be done by contract, under the close supervision of an officer of engineers.

The commercial importance of the work has been stated in previous reports from this office. Now that St. Louis is in direct railroad communication with Galveston Harbor, the importance of improving the latter has been greatly increased.

Commercial statistics will be found in my last annual report on improvement of inner bar, Galveston Harbor; also location of work and nearest light-house.

The plan of improvement here submitted has been carefully studied.

The details of construction are without precedent, but commend

themselves when the character of foundation offered is considered, lightness of structure being essential, and cheapness an important item at the present time.

If these proposed structures succeed, and I do not see reasons why they should not, many of our Gulf and lower Atlantic seaboard harbors can be improved in the same way and at less expense than by any other method.

One word in closing in regard to my abandonment of the project submitted to the Chief of Engineers in my letter of _____ recommending this survey.

This project was based on the supposed existence of a littoral current, constant in direction, and having sufficient velocity to make it effective for maintaining a channel scoured by the tides.

The observations of this survey do not prove the supposition correct, and have caused a change of plan to meet the actual conditions observed.

Respectfully submitted,

C. W. HOWELL,
Captain of Engineers, U. S. A.

IMPROVEMENT OF GALVESTON HARBOR AND ENTRANCE, TEXAS.

Report of Board of Engineers.

ARMY BUILDING,
New York, February 2, 1874.

GENERAL: I have the honor to transmit herewith—

1. The report of the Board of Engineers on Galveston Harbor, Texas, convened at New York City by virtue of Special Orders No. 9, C. S., from the headquarters Corps of Engineers, January 26, 1874. The estimate by the Board is appended to the report.

Very respectfully, your obedient servant,

Z. B. TOWER,
*Lieut. Col. of Engineers, Brevet Major-General,
Senior Member of Board.*

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

ARMY BUILDING, *January —, 1874.*

GENERAL: The Board of Engineers convened by the following order, viz:

[Special Orders No. 9.—Extract.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., January 26, 1874.

1. A Board of officers of the Corps of Engineers, to consist of Lieut. Col. Z. B. Tower, Lieut. Col. H. G. Wright, Lieut. Col. John Newton, and Captain C. W. Howell, will assemble at New York City, on January 28, 1874, or as soon thereafter as practicable, to consider and report upon the project submitted to this office, December 30, 1873, by Captain Howell, for the improvement of Galveston Harbor and entrance. Captain H. Heuer, Corps of Engineers, will act as recorder.

By command of Brigadier-General Humphreys:

THOS. LINCOLN CASEY,
Major of Engineers.

having assembled as directed, and continued its sessions from day to day till the present, have the honor to submit the following report:

The letter of instructions from your Office of the 26th instant desired the views of the Board "upon the practicability and probable cost of securing a permanently increased depth of water in Galveston Bay and entrance thereto by the plan submitted by Captain Howell, December 30, 1873," and the Board, therefore, confines its report within the limits embraced in those instructions, although its discussions have naturally taken a much wider range.

The question which first presents itself for consideration in the project is, whether it is probable that the two parallel piers proposed by Captain Howell, to extend from Fort Point and Bolivar Point over the outer bar to a depth of 18 feet water, would, if constructed, tend to increase the present depth and permit the ingress of vessels of greater draught than at present to Bolivar Channel, for it is obvious that any increase to the depth over the inner bar leading to the harbor of Galveston would be of no service unless the outer bar be improved, the depths over the two being at present about the same. In other words, vessels which can now pass the outer bar can proceed to the wharves at Galveston.

If the entrance between Fort Point and Bolivar Point were the outlet of a river merely, there might be grave doubts of the success of the plan of improvement presented, and the more so, if the problem were complicated by the existence of littoral currents strong enough to move the sands which compose the coast-line both above and below water. But it will be seen that, in the case before us, the Bay of Galveston (including East and West Bays) constitutes an immense basin or reservoir, which is filled to a certain extent on every flood-tide; this increase of water being discharged on the ebb with a velocity which, if confined by parallel piers and directed upon the bar, could hardly fail of producing an important scouring effect beyond what is now occasioned by the unconfined and wide-spread currents. Another advantage of the large interior basin referred to is, that the matter brought down by the rivers is all deposited in the upper portion of the bay, leaving only their waters, cleared of sediment, to pass out over the bar. The bar, therefore, is composed of matter from the Gulf and its shores without appreciable augmentation from the river deposits.

The Board is, therefore, of the opinion that, if piers proposed by Captain Howell were constructed, extending over the bar, the depth of water thereon would be increased in an important degree, though exactly what depth might be looked for cannot be predicted. It is also believed that the inshore extremity of the pier on the Fort Point side of the entrance, from the point where it connects with the bulk-head constructed by the city to where it joins the long, straight portion running to the bar, will have the effect of moving the bar at the Galveston Harbor entrance near to Bolivar Channel, whereby it will, to some extent, be carried off by the main current of the latter. This seems not only likely, but the work will have the effect of extending the extremity of Galveston Island northward, thus re-establishing the condition which existed when the depth over the harbor bar is represented to have been 30 feet. The two piers will therefore have the effect, in the opinion of the Board, not only of improving the outer bar, but also, incidentally, the inner bar at the entrance to Galveston Harbor.

The letter of instructions before referred to imposes the condition that an increased depth of water shall be "permanently" secured. If taken literally, this condition cannot, in the opinion of the Board, be fulfilled by the present project, nor by any other known method of im-

provement. Though the proposed piers will not secure an actual *permanency* of the depth at first attained, unless they should be from time to time extended, or the action of the ebb-current be aided at intervals by dredging or stirring, yet, under the favorable conditions which this locality presents for the application of the pier system, it is believed that the requirements of a practical permanency will, under the conditions before expressed, be fulfilled.

As regards the method of construction proposed by Captain Howell, the Board is compelled to speak with less confidence. The importance of some device for piers or training-walls for the improvement of our harbors, which shall be less costly than those hitherto practiced, is readily recognized. Piers of the length, and other dimensions suited to the case in question, if built of stone, resting upon the easily-moved sand, over which they would pass, would involve an outlay which the importance of the port would perhaps not justify, and which would not probably be provided for by Congress. If Captain Howell's plan should succeed—and it is impossible to say that it would not—it will supply the desideratum of a cheap method of construction which might be applied to many other localities where, otherwise, no attempts at improvement would be made in consequence of the necessarily heavy outlay they would involve. The Board therefore thinks it would be well to make a trial of the device, and would therefore recommend that it be tested by first constructing the inner end of the pier on the Fort Point side, and if found to succeed there, that the pier on the other side be commenced at its shore end, while, at the same time, a length of, say, from 300 to 500 feet be put down near the bar extremity of the same pier to test its efficacy in the most exposed position, the extremities of this detached portion being protected from the undermining action of the waves and currents by a suitable apron of bags of concrete or other material. By carrying out the shore end of the pier at the same time as, or before, the experimental portion on the outer bar, some idea can be formed as to the width to be given to the latter to enable it to withstand the violent action in that exposed position. As regards the height to which the piers or training-walls should be carried in order to obtain the desired depth, the Board does not feel able to express an opinion. Even if carried to the height of a single gabion only, an important effect may be expected, and if the action should not be sufficient it may be increased by adding to the height. It is, however, highly important, if not essential, that the gabion should be fitted with covers as well as bottoms, to prevent the scooping out of the sand-filling by the action of the sea in storms. This would necessitate their being filled through a hole left in the cover, by means of a funnel or hopper, or other device.

In a previous part of this report it was stated that the problem of improvement of the outer bar was not complicated by the existence of littoral currents. Such currents do exist, at times, but apparently result from the action of the wind. They run sometimes in one direction, again in the other, and in continued calm weather they are not discoverable. The greatest observed velocity did not exceed half a mile per hour—a velocity which in itself could hardly produce sensible action upon the sands of the bar or of the shoals above or below. The cause which produces the present changes on the bar is doubtless the action of the waves upon the sandy bottom, an action which is very largely increased during the heavy storms to which the coast is exposed. Such storms, when blowing directly or obliquely along the shore in either direction, will doubtless occasion the movement of large quantities of sand along the bottom and in suspension in the water; when directly

on shore this movement will be much less; but the inner bays will be filled to an unusual height with water from the Gulf, which, on the ceasing of the storm, will pour out of the bay and over the bar with great scouring power. Offshore winds drive out the water of the bay, thus producing an effect similar to that which follows the emptying of the surcharged bays after an onshore storm. It is represented that after such action as attends the two cases last mentioned the bar is invariably found in an improved condition.

As regards the works within the bay, designed by Captain Howell for the purpose mainly of increasing the width of the harbor of Galveston, and of improving the bar at its mouth, the Board is of the opinion that nothing should be done till the question of the practicability of permanently improving the outer bar shall have been demonstrated; and it therefore expresses no opinion thereon. Indeed, it would be impracticable to do so without more information regarding the strength and velocity of the currents than the present survey affords.

A much more extended series of observations would be necessary to a satisfactory conclusion; but these may be readily made whenever favorable results from the works for the improvement of the outer bar shall justify the attempt to improve the inner harbor.

A revised estimate for the two main or outside piers C D and E F is annexed.

Respectfully submitted.

Z. B. TOWER,
Lieut. Col. of Engineers, Brevet Major-General.
H. G. WRIGHT,
Lieut. Col. of Engineers, Brevet Major-General.
JOHN NEWTON,
Lieut. Col. of Engineers, Brevet Major-General.

Generally concurring in the report of the Board, I sign it, reserving explanations and points of dissent, viz:

It is my opinion that such dredging as will be required can be performed by the least expensive method in general use, viz, dragging a harrow through the channel, using a small tug already belonging to the work.

While not positive as to the entire adequacy of the character of construction proposed, I yet have more confidence in it than the other members of the Board.

I do not agree with the Board in the increased estimate submitted, but continue in the belief that the estimate submitted with my report should be adequate, provided appropriations for construction be made in time and magnitude to keep work in progress throughout each year, with the largest force that may be employed to advantage.

C. W. HOWELL,
Captain of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

The following is the estimate presented by Capt. C. W. Howell, Corps of Engineers, as the probable cost of the two outer piers C D and E F on which the estimate of the Board is based:

	Feet.
Length of jetty C D.....	20, 800
Length of jetty E F.....	16, 200
Total	37, 000

The number of gabions for both piers placed in two rows and one tier high is 12,333, at \$30 each	\$369,990
Filling the same, 77,488 cubic yards, at 50 cents	38,744
Total	408,734
Raising the piers C D and E F by a second tier will require 18,499 gabions, at \$30 each	554,970 00
Filling same, 116,229 cubic yards, at 50 cents	58,114 50
Total	613,084 50
Making the total cost of the two piers	1,021,818 50
Add ten per cent. for contingencies	102,181 85
Total amount of Captain Howell's estimate	1,124,000 35
Additions to the above estimates by the Board :	
Adding a top cover to 30,832 gabions, at \$3 each	92,496 00
Increasing thickness of 30,832 gabions, from 4 to 6 inches, at \$10	308,320 00
Covering heads of 30,832 gabions with asphalt, at 25 cents	7,708 00
It is difficult to estimate the cost of placing and filling the gabions, but on the supposition that an average of 15 per day throughout the year can be placed in position, it is estimated that the cost per gabion will be \$10. 30,832 gabions, at \$10 each, \$308,320.	
Being an excess over Captain Howell's estimate of	211,461 50
Cost of wire-fastenings for 30,832 gabions, at 50 cents	15,416 00
Total	635,401 50
Add Captain Howell's estimate	1,124,000 35
Total estimate of Board for the two outer piers, if raised two tiers high	1,759,401 85

R 8.

IMPROVEMENT OF REDFISH BAR IN GALVESTON BAY, TEXAS.

This work, for which an appropriation of \$10,000 was made June 23, 1874, is but an extension of the work reported on pages 634 and 635 Report of the Chief of Engineers for 1873. The work there reported complete, answered the then existing wants of commerce.

Since, a deeper and wider channel than it afforded through Redfish Bar, has become desirable.

The money now available will be expended in deepening and widening the channel but is not considered sufficient to complete the work.

The work is located in the collection-district of Galveston and near the light-house on Redfish Bar.

Financial statement.

Amount in hands of officer and subject to his check July 1, 1873	\$68 41
Amount appropriated by act approved June 23, 1874	10,000 00
Amount expended during fiscal year ending June 30, 1874	50 00
Amount available July 1, 1874	10,018 41

Estimate for completion of the work will be submitted in December next, it being deemed advisable to await the results of the present appropriation before recommending another.

Total amount appropriated	\$20,000 00
Total amount expended	9,981 59

R 9.

SURVEY FOR LOCATING THE TERMINUS OF THE FORT ST. PHILIP CANAL
UNDER THE LEE OF SABLE ISLAND.

This survey was projected on the following suppositions :

1st. That a sheltered harbor excavated under the lee of Sable Island with a breakwater located on the shoal ground to the northward, if practicable, would be preferable as an entrance to the projected canal, to an entrance projected from the front of Sable Island directly into the throat of Breton Island Pass.

2d. That by inclosing Grand Bay a tidal reservoir might be established, receiving and discharging through the entrance to such harbor and thus creating currents sufficiently powerful in scouring effect to maintain the depth of entrance given to the harbor.

3d. It was assumed that this direction given the entrance would necessitate artificial works interfering the least with the flow of tidal currents through Breton Island Pass; that protection of the west end of Breton Island would be perhaps rendered unnecessary, and that a breakwater on the shoal between the east and west forks of Breton Island Pass, while protecting the entrance to the harbor from the north, might be so planned as to deepen and lengthen the west (or harbor) fork.

4th. It appeared evident that the entrance, so located, could be better protected by fortification on Sable Island than if located at any other point.

The survey of 1871 and 1872 gave all the data for considering this location, except—

1st. Borings and soundings along the line of probable location of the trunk of canal.

2d. For inclosure of Grand Bay.

These data are now presented in the following report and on the chart herewith :

UNITED STATES ENGINEER OFFICE,
New Orleans, La., May 25, 1874,

SIR: I have to make the following report on the "survey for locating the terminus of the Fort St. Philip Canal under the lee of Sable Island." The survey was commenced March 19, 1874, and the field-work was finished April 22, 1874.

The triangulation, soundings, level-line, and sections of borings, have been plotted on a single sheet, which is submitted herewith.

A tide-gauge was established at Camp Howell, in Mississippi River, and another near station 6, in Grand Bay. A level-line has been run from Camp Howell to station 2, and from station 2 to the tide-gauge in Grand Bay. Taking high-water of 1874 as the plane of reference, we have plotted the section of the proposed route so as to show low-water in Mississippi River, 1872. Its reference is 6.45 feet.

Extreme high-water in Grand Bay, for time covered by survey, 2.13 feet.

Mean low-water in Grand Bay, for same period, 5.40 feet.

Extreme low-water in Grand Bay, for same period, 7.03 feet.

In order to preserve the record of this work five bench-marks have been established.

Bench-mark No. 1 is the top of a stake at the northwest corner of the house at Camp Howell. It is 0'.66 below the zero of the gauge at Camp Howell, and its reference is 0'.76.

Bench-mark No. 2 is the top of a piece of 1-inch round iron, driven into the end of a yellow-pine stick, 3' by 12" by 12", buried in the ground and standing upright near the northeast corner of house at Camp Howell. It is 4'.85 from the northeast corner of the house, and 15'.45 from northwest corner of the house. This bench-mark is 1'.03 below the zero of the tide-gauge at Camp Howell, and its reference is 1'.13.

Bench-mark No. 3 is the head of a $\frac{1}{4}$ -inch by 16-inch iron bolt, driven into the end of a cotton-wood log, 3 feet long, buried in the ground, standing upright, near the southeast corner of the house, at Camp Howell. It is 6'.05 from this corner and 16'.05 from the southwest corner of the same house. This bench-mark is 1'.83 below the zero of the tide-gauge at Camp Howell, and its reference is 1'.93.

Bench-mark No. 4 is a stake 82'.5 from station 6, in the direction of station 2, (see

chart.) The top of the stake is 2'.36 below the zero of gauge in Grand Bay. Its reference is 3'.99.

Bench-mark No. 5 is the head of a $\frac{1}{2}$ -inch by 16-inch iron bolt, driven into the end of a cotton-wood log, 3' by 15", buried in the ground, standing upright, 49' from station 21, in the direction of station 2. This bench-mark is 2'.49 below the zero of the gauge in Grand Bay, and its reference is 4'.12.

Seven borings have been made, 4 to a depth of 100', 1 to 97', 1 to 79', and 1 to 4.

The sections of the different strata are shown on the next sheet.

The specimens, 56 in number, are properly numbered for each boring, and the depth from which the earth was taken is indicated on each specimen. The location of each boring is indicated on the chart.

A hydrographic survey has been made of Grand Bay. This work can be added to our general chart by reducing the scale to 30000.

I have estimated the amount of excavation for the proposed route (Δ 2, to Δ 8, see chart) from the end of the lift-lock to 27 feet water in the Gulf.

Width of canal at bottom, 200 feet; depth at extreme low-water, 25 feet; depth at mean low-water, 27 feet, (26.63.) Side slopes $\frac{1}{2}$.

The outer end of the canal to be 1,000 feet wide for a distance of $\approx$ 075 feet. Total excavation in cubic yards, 10,203,915.

I have also estimated for the breakwater and jetty, indicated on the general chart.

Breakwater:

Breakwater to have a section similar to the construction at Rotterdam, length 11,600 feet.

Depth at east end, 21 feet.

Depth at west end, 14 feet.

Width at top, east end, 30 feet.

Width at top, west end, 20 feet.

Cubic yards, fascines and ballast, 368,479.

Cost, at \$5 per cubic yard, \$1,842,395.

Jetty:

Length, 11,100 feet.

Depth at outer end, 11 feet.

Cubic yards, fascines, and ballast, 87,704 feet.

Cost, at \$5 per cubic yard, \$438,520.

Sections of the bayous, on the south side of California and Grand Bays, have been made as directed by you.

Each section is lettered, and the corresponding letter on the general chart indicates the approximate location of the section.

Very respectfully, your obedient servant,

H. M. ADAMS,
Lieutenant of Engineers.

Capt. C. W. HOWELL,
Corps of Engineers, U. S. A.

The work is located in the collection-district of New Orleans, near Fort St. Philip, La., and the nearest light-house is that at the head of the passes.

R 10.

SURVEY OF THE NECHES AND ANGELINA RIVERS, TEXAS, MADE IN COMPLIANCE WITH SECOND SECTION OF ACT OF JUNE 10, 1872.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., December 30, 1873.

GENERAL: I have the honor to forward herewith report on survey of the Neches and Angelina Rivers.

The recommendations made by Lieut. H. M. Adams meet my approval.

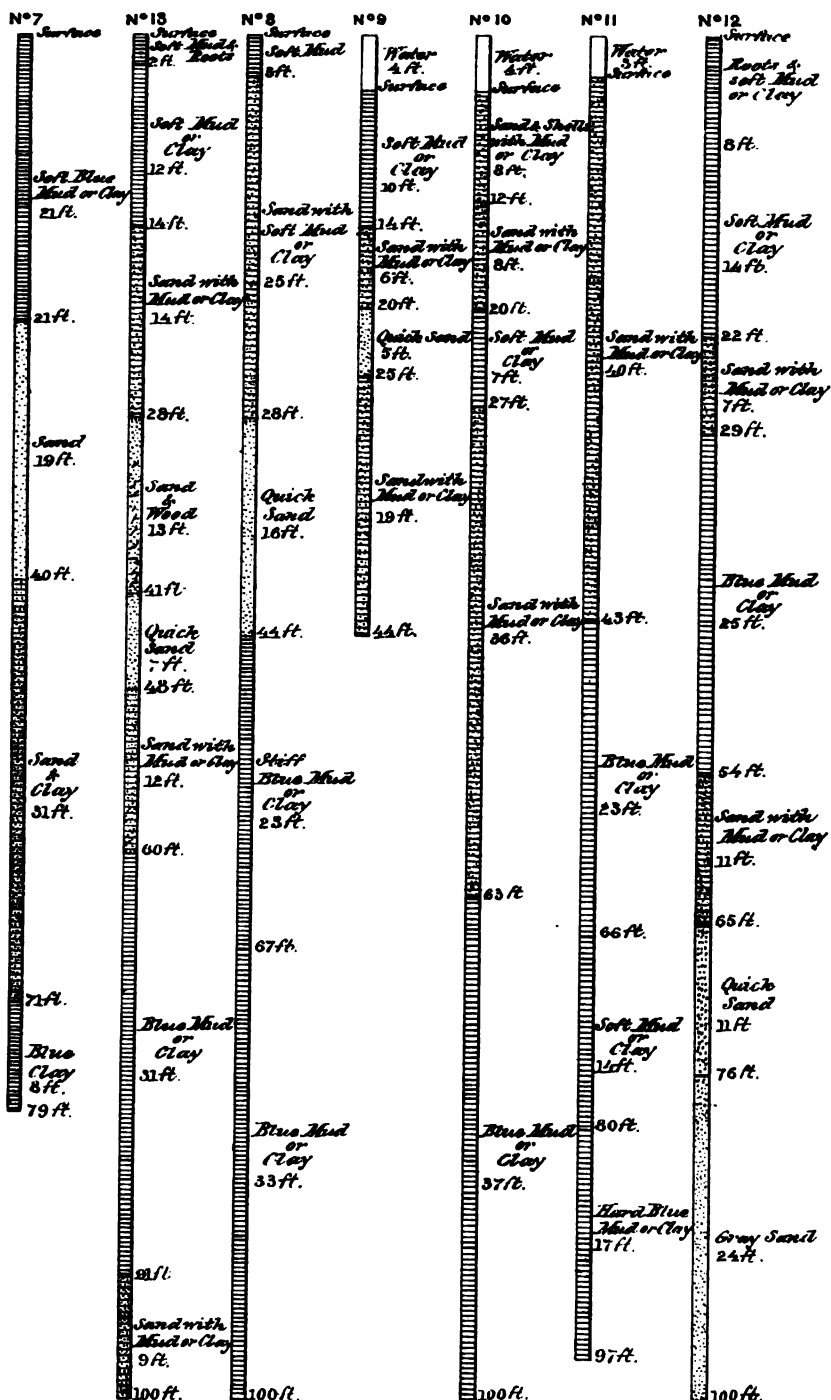
The charts to accompany this report were forwarded to the Chief of Engineers, September 29, 1873; five sheets.

Very respectfully, your obedient servant,

C. W. HOWELL,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

SECTIONS OF BORINGS



Report of Lieut. H. M. Adams, Corps of Engineers.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., November 22, 1873.

SIR: I have to make the following report on the survey of the Angelina and Neches Rivers, Texas:

THE ANGELINA RIVER.

This survey was commenced November 9, 1872, and the field-work was finished December 21, 1872. The Angelina is a tributary of the Neches. Our survey was extended from the junction of the two rivers to Platonía, one hundred and four miles. This river is only navigable during high-water, which lasts but a small part of the year. The principal product of the country drained by the Angelina is cotton, and much of it finds its way to market by the great northern railroad before the annual rise in the river, which makes the stream navigable. A few trips are made up the river each year by the steamboats Laura and Graham, the only boats now engaged in this trade.

For a complete description of the river and of the obstructions to navigation, reference is made to the report of Mr. A. De Man, which is appended, marked "B." With this report are submitted two charts, giving the plan and numerous cross-sections of the river. No recommendation is made for the improvement of the Angelina, because no improvement seems to be required.

THE NECHES RIVER.

Our field-work was commenced December 25, 1872, and finished April 2, 1873. The survey extended from the mouth of the river to Boonville, one hundred and ninety-five and one-half miles. The Neches is navigable, at all stages of water, to a point known as Weiss Bluff, fifty-one miles from the mouth. The river above Weiss Bluff is only navigable during high-water.

There are, at present, three steamboats—Stonewall, Laura, and Graham—engaged in the navigation of the Neches; a large amount of lumber is annually shipped by sailing-vessels from the Lower Neches to Sabine Pass and Galveston. The principal obstruction to the navigation of the river is the bar at its mouth in Sabine Lake. The depth of water on this bar is 3 feet at low-tide, and the distance across the bar from 5 feet depth on one side to 5 feet depth on the other side, is 6,850 feet. The bar is composed of fine sand and mud, and is formed by the deposit from the river-water.

The following estimate is submitted for excavating a channel across the bar in a straight line, from A to B, (see chart No. 3,) 80 feet wide and 5 feet deep.

Cubic yards of excavation, 47,851.	
Cost, at 50 cents.....	\$23,925 50
Add 10 per cent. for contingencies.....	2,392 55
Total	26,318 00

Statistics showing the amount of trade at Sabine Pass have been collected. This information is appended, and marked "A," of the imports and exports; about one-third of the amounts stated belong to the Neches River trade.

For the details of our field-work, description of the river, and number and character of the obstructions to the navigation of the river, reference is made to the report of Mr. A. De Man, which is appended and marked "B." Three charts of this survey are also submitted herewith.

Very respectfully, your obedient servant,

H. M. ADAMS,
Lieutenant of Engineers.

Capt. C. W. HOWELL,
United States Engineers.

A.

COMMERCIAL STATISTICS.

CUSTOM-HOUSE, GALVESTON, TEXAS.
Collector's Office, February 17, 1873.

SIR: I submit herewith a statement of the commerce of the port of Sabine Pass for the years 1871 and 1872.

It may be well to observe that Sabine Pass is a port of delivery only, and hence all imports are indirect, having been first entered at New Orleans or this port as foreign merchandise.

All exports are made coastwise only.

I am, sir, very respectfully,

E. L. STONE,
Deputy Collector.

H. M. ADAMS,
Lieut. U. S. Engineers.

Report of deputy collector of Sabine Pass relative to the commerce of that port for the years 1871 and 1872, ending December 31.

	1871.	1872.
Entered, steam	48	51
Entered, sail	648	699
Cleared, steam	48	51
Cleared, sail	648	699
	<u>1,392</u>	<u>1,450</u>
TONNAGE.		
Entered, steam	36,336	32,454
Entered, sail	29,268	30,068
Cleared, steam	36,336	32,454
Cleared, sail	29,268	30,068
	<u>131,208</u>	<u>137,044</u>
Imports, dutiable	\$251,427	\$277,543
Imports, free	502,851	554,066
	<u>754,278</u>	<u>831,609</u>
Exports, domestic	1,368,937	1,506,731

STATISTICS OBTAINED FROM MR. F. P. HARRIS, MERCHANT, AT SABINE PASS.

Imports from September 1, 1871, to September 1, 1872, for Sabine Pass: 31,500 barrels of miscellaneous merchandise.

For places on the Neches and Sabine Rivers: 16,000 barrels miscellaneous merchandise.

Exports: 12,446 bales cotton; 275 bales sea-island cotton; 12,750 hides; 115 barrels tallow; 18 barrels beeswax; 33 hogsheads tobacco; 70 bundles deer-skins; 50 bags wool; 2,600,000 feet (board-measure) lumber; 26,000,000 shingles; 300 head cattle.

Report of Mr. A. De Man, Assistant Engineer.

B.

GALVESTON, TEXAS, July 26, 1873.

DEAR SIR: On the 21st of October, 1872, I received orders from you, assigning me to the duty of making a survey of the Angelina and Neches Rivers, including the bar of the latter in Sabine Lake. The order read as follows:

"You will proceed from Galveston to Crockett, in Houston County, and from there across the country to Platonía, on the Angelina River. The survey is to extend from Platonía down the river to its junction with the Neches; then up the Neches to Boonville, or Boon's Ferry; then, commencing at the junction of the Neches and Angelina Rivers, the survey will be continued down the Neches to its mouth in Sabine Lake, including the bar at the mouth of the river.

"At Platonía you will procure two small boats and hire two laborers.

"The rivers are to be meandered on one side with the transit and stadia, locating frequent points, by triangulation or stadia, on the other side; this will require yourself following down one bank with transit, and two men, one on each bank, with stadia.

"In going from point to point, channel-soundings can be taken from the boats and approximately located; cross-sections should also be made, noting at the same time the height of high and low water.

"Where bars are found, their general characteristics are to be noted. Approximate heights and character of banks are to be observed, and clearings on banks to be located. All snags, leaning trees that would obstruct navigation, and all rafts are to be located and described sufficiently to permit of an estimate of the probable trouble and cost of removing them.

"All information to be obtained from people residing on the banks of the river regarding the productions of the country, low-water and flood marks, and other general information of possible value in deciding how the country may be benefited by improving the navigation of the river, should be collected. County maps may be made use of to expedite your work, provided you prove them by frequent checks.

"The entire amount of money available for this survey and for the office-work is \$2,400. Your expenses must be regulated accordingly. You will take duplicate receipts in the proper form for all expenditures, and will let me know by letter of your progress as often as possible.

"After finishing your work at the mouth of the Neches you will return to Galveston, by way of Sabine Pass, with as little delay as possible."

In accordance with the above instructions I started immediately. At Platonía I found but one plantation, which had been recently abandoned. I was, therefore, obliged to go to Marion, where I arrived October 25. Some difficulty in completing my outfit and obtaining the necessary help detained me there till November 7, when I started for Platonía, and commenced the work November 9. From the amount of money appropriated and the extent of the work, I concluded that merely a compass-survey was expected.

My method of proceeding was as follows: Each one of my two men had charge of a skiff and a stadia-rod. I stationed skiff A at station O, and went down the river with skiff B to station I, where I set up the instrument, sending skiff B to station II, and taking the stadia-reading and magnetic course to station O, after which I flagged him down. By this time skiff B had reached its position, and while skiff A was coming down I took the stadia-reading and magnetic course to station II; then I stepped into skiff A, which took me down to station III, where I repeated the operations as at station I, and so continued.

The field-notes were kept in the following manner:

On the left page, in a central column, were recorded the stadia-readings, occupying the place of corresponding stations, and between them the magnetic course of the line of sight. From each position of the instrument there was a back-sight and a fore-sight. The fore-sight, being directed down the river, was recorded as it read on the compass; the back-sight was reversed, so as to obtain in the field-book the magnetic bearings of all the lines in one direction. In two other columns, to the left, were recorded the angles of elevation or depression of the line of sight corresponding to each stadia-reading.

Between the numbers of the succeeding stadia-readings and on each side of the central column were sketched the shore-lines, representing them for each sight, as the column would have been formed by the splitting of the line of sight.

In all cases where the curvature of the river was too complicated to be represented by this system, additional sketches were taken on the right-hand page.

Cross-sections were taken by setting the instrument at the most convenient bank and locating from there a line of cross-section at right angles with the stream, noting the distances to the several points of the slopes by stadia-readings.

Soundings were taken on the same line. These notes were recorded on the right-

hand page in four columns, one for the stadia-distances, two for the corresponding elevation or depression, and one for the soundings.

In surveying down the river, the position of succeeding stations was sometimes on the same bank, sometimes on opposite banks, according to the direction of curvature of the river, or the obstructions of the line of sight by overhanging trees.

This gives, in plotting, a series of points on the right and the left bank between which the stream can be sketched.

SURVEY OF THE ANGELINA RIVER.

The stage of the water during the survey of the river from Platonis to Bevilport was from 2 to 4 feet above low-water. Even with that rise I found a great many places where the river was so obstructed by logs and fallen trees that it was impossible to get through, even with my small skiffs. We were thus compelled to unload them and lift them over the obstacles. This occurred several times each day, and was a serious detention in the progress of the work.

At Bevilport, several days of rain produced a rise in the river of about 13 feet above low-water, as shown by the map and cross-sections.

The distances run each day are as follows:

Dates.	Distances.	Remarks.
1872.	<i>Feet.</i>	
November 9..	13, 719	
10..	16, 584	Sunday.
11..	16, 584	At Marion; completed outfit.
12..	13, 887	
13..	12, 660	
14..	15, 379	
15..	18, 445	
16..	11, 738	
17..	-----	Sunday.
18..	20, 392	
19..	16, 770	
20..	17, 700	
21..	7, 264	Brown's Ferry; stopped 3 hours repairing boats.
22..	18, 186	Observed north star; mag. var. $8^{\circ} 24'.$
23..	16, 316	
24..	-----	Sunday.
25..	6, 729	Stopped at 12 a. m. on account of rain.
26..	17, 229	Could not work till 11 a. m. on account of fog.
27..	13, 953	
28..	17, 070	Passed Worden's Ferry.
29..	21, 335	
30..	22, 316	
December 1..	-----	Sunday.
2..	26, 321	Passed Taylor's Ferry.
3..	13, 292	Townsend's store; stopped for supplies.
4..	23, 883	
5..	-----	Stopped on account of rain.
6..	-----	Rain.
7..	17, 697	
8..	-----	Sunday.
9..	24, 125	Arrived at Mayer's Ferry.
10..	-----	Stopped on account of rain.
11..	22, 619	
12..	17, 724	Arrived at Morris Ferry.
13..	21, 138	
14..	24, 268	Passed Bohler's Ferry.
15..	-----	Sunday.
16..	21, 951	Arrived at Bevilport.
17..	-----	Stopped on account of rain.
18..	-----	Do. do.
19..	-----	Do. do.
20..	9, 161	Started at 12 a. m.
21..	29, 758	Arrived at the junction.

Number of days coming from Platonía, 43; number of days actually at work during that time, 31; distance from Platonía to the junction, 103.82 miles; average run for each day's work, 3.34 miles.

GENERAL DESCRIPTION OF THE RIVER.

The river winds its way tortuously through a valley varying in width from one to five miles. These bottom-lands are very rich, owing to the alluvion deposited by yearly overflows; but the irregularity and duration of these overflows prevent their use for agricultural purposes.

They are merely used for pasturing the different kinds of stock, which find here an abundant growth of cane, and, during the season, plenty of mast. They are also covered with several varieties of oak, gum, elm, ash, beech, magnolia, sycamore, and cypress trees.

The river often reaches the limits of the valley, and there the higher lands are covered with pine timber, which is generally the growth on the rolling lands on either side of the valley.

There are but few settlements on the river, and from the fact that several of them have been abandoned and a great many fields not being in cultivation, it would appear that in this part of the country there has been, for the last few years, a lack of agricultural activity, or, at least, a want of labor.

I could not obtain sufficient information in regard to the productions of the surrounding country.

The most important product supporting the navigation is cotton, which used to be mostly shipped by flat-boats or steamboats, but since the completion of the Great Northern Railroad a great many people prefer this surer way to send their products to market, on account of the river being navigable only during high water.

The season of the freshet is very irregular, and it has been known to fail to such an extent as not to permit navigation. There are large forests of pine and cypress timber, for which the river is a cheap and the only way by which it can be floated to the saw-mills on the lower part of the river.

The river at low-water is but a large creek, and is entirely unfit for navigation of any kind. The yearly freshet produces a rise of water from 10 to 24 feet; then the stream has a width varying with the height of the water, from 80 to 100 feet at the head of navigation to 200 or 250 at the junction, but is obstructed by overhanging trees, logs, and snags.

Distances to the several landings.

	Feet.	Miles.
From Platonía to Marion.....	30, 303	5. 73
Brown's Ferry.....	159, 324	30. 17
Worden's Ferry.....	237, 619	45. 00
Taylor's Ferry.....	308, 516	56. 37
Townsend's Landing.....	335, 885	63. 61
Mayer's Ferry.....	401, 589	76. 05
Lewis Morris's Ferry.....	441, 932	83. 69
Bohler's Ferry.....	469, 614	88. 94
Bevilport.....	509, 289	96. 45
Junction.....	548, 208	103. 82

The statements I collected from people living on the river with regard to low and high water stage were very contradictory. I have, therefore, been obliged to take the mark left by the water on the timber, which is the most reliable, but not always very well defined. It is to these heights that I refer in the cross-section shown on the map as the average of high-water.

The low-water mark is the nearest that I could estimate from the contradictory statements.

It will be noticed that the difference between high and low water is not the same in all the cross-sections. These differences can be accounted for by the fact that in parts of the river where high banks confine the greater portion of the water to the channel it will rise higher than in places where the low banks permit it to overflow more freely into the bottom-lands. The height of the banks is from 15 to 25 feet above low-water.

The bends of the river are generally very short, having a very abrupt bank on the outside and a sloping bank on the inside. At the time of freshets, the water sweeping along the outside wears away the bank and washes in large trees which often entirely obstruct the river; these are sawed or chopped off by raftsmen, flatboat-men or steamboat-men, who generally do the work with the least expense possible, but most of the time to the disadvantage of the river; the trunk with all its limbs, being dropped, forms afterward a bad obstruction, the stump and roots soon wash in to the channel and form a dangerous snag.

The inside of the bend is generally covered with a dense growth of willows leaning toward the stream. They increase very much the difficulty of passing the sharp bends.

There are a few rocky shoals located on the map, but the river being only navigable at high-water they are not material obstacles at that stage.

The time of high river is very irregular, but from January to May may be taken as an average for the navigable season.

The snags and other obstructions to the navigation were too numerous to be located on the map. In the following columns are given the number of obstructions in two sections of the river:

Locality.	Distances.	Overhang- ing trees.	Logs.	Snags.
	<i>Miles.</i>	<i>No.</i>	<i>No.</i>	<i>No.</i>
From Platonia to Morris Ferry.....	83. 69	1, 438	1, 661	603
From Morris Ferry to the junction.....	20. 13	242	187	172

IMPROVEMENTS.

The river being unfit for low-water navigation, it will only be necessary to remove the obstructions above low-water, so as to make the navigation safe with a rise of six feet of water, this being the least rise with which the steamboats can go up the river, owing to occasional falls in the water, by which the boats are sometimes left on shoals for weeks.

The limited business of the country would not justify the heavy expense of removing the snags and logs from the bottom of the river; therefore I would suggest that dangerous snags and logs above low-water should be cut up into short pieces, which would then be carried away by the next freshet, or sink to the bottom out of the way.

The overhanging willows should all be cut down and chopped into pieces small enough to float without obstructing the river. This improvement cannot be expected to be a permanent one, because a new growth of willows will start on the same place, and would have to be cut down after some years. Large overhanging trees, generally on the outside of the bends of the river, should be treated in the same way.

All of this timber, if properly cut up, will float down the river to some place where it overflows, and there drift into the bottom-lands, where the trees and brush will retain it.

It is plain that these improvements should be made gradually; that is to say, to divide the work into four or five years, for if all the timber were to be cut in one year it might seriously injure the navigation of the river.

A great many large trees are standing close to the edge of the banks, and their slow vibration from the action of the winds, combined with the wearing of the banks by the current, causes large cavings, forming serious obstructions. Such trees should be dealt with differently from what was done some years ago by parties under a contract with the State of Texas for improving the river.

In this case all such trees were girdled; some of them are standing yet and are a serious danger to the navigation; steamboats and flat-boats are often driven by the current against the banks in proximity to such dead trees, which have been known to fall on the decks, endangering the lives of passengers and crews, besides causing great damage.

In my opinion the better way of dealing with such trees would be to cut them down, leaving a stump tall enough to keep the trunk horizontal, in case the stump should afterward be washed into the river, and thus prevent its making a sawyer, but in most cases the force of the winds acting only on the top of the tree would be done away with, and the roots would strengthen the banks and thus prevent some of the cavings.

In case any work should be done on the river, special attention should be given to the places marked on the map as cut-offs, which are channels of recent formation and could generally be made good passages by cutting trees and taking out stumps which obstruct them.

Several other places where two bends of the river come close together, and where the water at high stage runs across the banks, could be made good cut-offs by making a judicious choice in the cutting of the trees. The water then would soon wash its way through.

These cut-offs, besides shortening the distance, would generally avoid bad bends of the river.

According to the statements of the people living on the river, the previous improve-

ments attempted by the State have proved to be a failure. This was owing to the incompetency of the men in charge of the work and to the contract system. It seems to me, also, that the money, if any should be appropriated, could be spent more properly under the superintendence of an experienced foreman.

SURVEY OF THE NECHES RIVER.

This survey was commenced at the junction of the Angelina River, being there with my party after the completion of the survey of the latter river.

I could not, as my order stipulated, get up to Boonville; the water being high, the current was too swift to go up by the river. The communication by land was also too difficult, the bottom-lands being overflowed; and moreover, there being no settlements within reach, where I could secure transportation, I concluded to work down the river, calculating to take the first steamboat going to Boonville, but none went up until the survey of the Lower Neches was completed, including the bar at the mouth.

At the time of the survey some parts of the river were overflowed, having both banks from 2 to 6 feet under water. This made the work very difficult, and in order to prosecute it at that stage of water I was obliged to build scaffolding in the trees on the banks in order to set up the instruments.

The delay resulting from this, and the loss of time in going to the upper river and waiting for help, protracted the work longer than was anticipated.

Record of daily work.

Dates.	Distances.	Remarks.
1872.	<i>Feet.</i>	
December 25	24, 836	
26	28, 198	
27	26, 369	Arrived at Town Bluff.
28	-----	Stopped to get supplies and send to Gaspar for letters.
29	-----	Sunday.
30	20, 053	Fog in the morning.
31	25, 127	Fog in the morning; passed by Horn's Ferry.
1873.		
January 1	3, 966	Stopped work on account of rain.
2	20, 244	Passed Work's Landing.
3	29, 443	Arrived at Arline's place.
4	-----	Stopped on account of rain.
5	-----	Sunday, (lost skiff.)
6	-----	Went to buy a skiff.
7	27, 767	Passed Wright's Landing.
8	41, 546	
9	37, 309	
10	24, 613	Stopped at Yellow Bluff 2 hours for repairs.
11	34, 538	
12	-----	Sunday.
13	29, 101	Passed Bearman's Bluff.
14	34, 086	
15	28, 223	Richardson's Bluff; observed United States magnetic variation, 8° 19'.
16	29, 456	
17	30, 660	
18	22, 782	Arrived at Weiss Bluff.
19	-----	Sunday.
20	30, 882	
21	35, 737	Passed Plateller's Bluff.
22	52, 917	Passed Bunn's Bluff.
23	11, 717	
24	-----	At Beaumont stopped for repairs.
25	-----	Do.
26	-----	Sunday.
27	-----	Waited for help.
28	-----	Do.

Record of daily work—Continued.

Dates.	Distances.	Remarks.
1873.	<i>Fect.</i>	
January 29	.....	Waited for help.
30	17, 895	Started at 12 a. m.
31	24, 168	
February 1	17, 500	
2	.....	Sunday.
3	9, 356	Stopped on account of wind.
4	20, 910	Passed Smith's mill.
5	18, 907	Stopped on account of fog in morning.
6	12, 360	
7	16, 133	
8	4, 637	Finished survey of lower river.
9	.....	Sunday; observed United States magnetic variation, $8^{\circ} 21'$.
10	.....	Established camp at the mouth.
11	.....	Built signals.
12	.....	Built signals and scaffoldings.
13	.....	Do.
14	.....	Rain the whole day.
15	.....	Do.
16	.....	Sunday.
17	.....	Built signals and scaffoldings.
18	.....	Ran base-line.
19	.....	Thick fog in morning; completed scaffoldings.
20	.....	Fog in the morning; ran shore-line in afternoon.
21	.....	Taking readings for triangulation.
22	.....	Do.
23	.....	Sunday.
24	.....	Removed camp.
25	.....	Waited for help.
26	.....	Do.
27	.....	Testing base-line.
28	.....	Put up ranges in the lake.
March 1	.....	Do.
2	.....	Sunday.
3	.....	Put up ranges in the lake.
4	.....	Do.
5	.....	Taking soundings; stopped part of the day on account of wind.
6	.....	
7	.....	
8	.....	Taking soundings.
9	.....	Sunday.
10	.....	Put up ranges and took soundings.
11	.....	Do.
12	.....	Do.
13	.....	Finished the work at the bar.
14	.....	Waited for steamboat to go up the river.
15	.....	On steamboat going up the river.
16	.....	Do.
17	.....	Do.
18	.....	Do.
19	.....	Do.
20	.....	Do.
21	.....	Do.
22	.....	Arrived at Boonville; built skiff.
23	.....	Sunday.
24	.....	Built skiff.
25	.....	Built skiff; observed United States magnetic var., $8^{\circ} 34'$.
26	26, 393	Left Boonville.
27	29, 841	Passed Martin's Ferry.
28	33, 656	
29	13, 573	Arrived at Jordan's Ferry.
30	.....	Sunday.
31	50, 443	

Record of daily work—Continued.

Dates.	Distances.	Remarks.
1873.	<i>Feet.</i>	
April 1	53, 130	
2	4, 764	Finished survey of Upper Neches.
3	.....	Rowed down the river.
4	.....	Do.
5	.....	Do.
6	.....	Sunday; arrived at Beaumont.
7	.....	Left with steamboat for Sabine Pass.
8	.....	At Sabine Pass.
9	.....	Went on board of schooner.
10	.....	On way to Galveston.
11	.....	Arrived at Galveston.

Number of days on the river, 70.

Number of days actually at work, 39.

Distance from Boonville to the mouth, 195.56 miles.

Average number of miles run each working-day, 5.01 miles.

Number of days at the month, 33.

Number of days actually at work, 22.

GENERAL DIVISION OF THE NECHES RIVER.

The river may naturally be divided into two parts; the lower part, navigable at low-water stage, and the upper part, only navigable at high-water.

The part navigable at low-water extends up to Weiss Bluff, according to the statement of the people living on the river, and of the captain of the steamboat Graham, which run up there the whole of last summer. It is also said that the tide is felt at this point.

A portion of the upper part of the river from Boonville to the Angelina Junction is nearly in the same condition as the Angelina River, with the exception that the bends are not quite so abrupt; the banks are generally higher and sometimes rocky.

At the time of the survey, the water being high, I could notice but one place where the rocks in the channel of the river obstruct the navigation at that stage. At a place located on the map are two points of rock running out from the right bank to the center of the channel. They are at water-surface when it is about 9 feet above low-water, and being on the outside of a bend they endanger the navigation at that place very much. According to some statements this is the only dangerous rocky place.

The other portion of the upper river, from the junction to the Weiss Bluff, is in better condition with regard to the overhanging timber; the captains of the steamboats which, at high water, run regularly to Bevilport, cut more or less trees every year. The stream is generally wider, with the exception of some places where the banks are low; the water overflows the bottom and there is but little current in the channel, which is the cause of its being narrow and very crooked.

The river is especially in that condition for the ten or twelve miles immediately above Weiss Bluff.

The portion of the lower river between Weiss Bluff and Bunn's Bluff is comparatively in good condition, there being but few logs and snags, and a very small number of overhanging trees; at low-water stage a few sand-bars reduce the width of the channel so as to make it difficult for boats drawing three feet of water to get by them.

At the time of the survey, the water being high, I could not notice them, but, according to the statement of the captain of the steamboat Graham, they are formed by snags, and if they were removed from the bottom the sand would soon wash away. The width of this portion of the stream ranges between 200 and 300 feet at high-water stage.

The portion of the river between Bunn's Bluff and the mouth is in good condition. There are but very few snags, logs, and overhanging trees. A few miles below Beaumont the timber gives out, and the river winds its way through a low marshy country to Sabine Lake. This is favorable for sailing-vessels, which run regularly to Beaumont and to the surrounding saw-mills. Their principal trade is lumber, to which the above country furnishes an abundant supply of several varieties of timber, mentioned in the description of the upper river.

Schooners run up as far as Bunn's Bluff and Concord, on Pine Island Bayou, a tributary of the Neches.

The width of this portion of the stream ranges between 400 and 900 feet.

The yearly freshets have little effect on the height of the water in this part. The average may be estimated at five feet, and the rise and fall, owing to the tides, are the most noticeable variations in the stage of the water.

The villages located immediately on the stream are of no material importance, Beaumont being the only business center worthy of mention.

Distances to the several landings.

	Feet.	Miles.
From Boonville to Martin's Ferry.....	31,615	6.00
Greenwood's Landing.....	47,722	9.00
Hopson's Landing.....	122,840	23.26
Jourdan's Ferry.....	132,410	25.07
Delano's Ferry.....	159,924	30.02
Thomson's Bluff.....	220,636	41.59
Angelina Junction.....	240,747	45.78
Tower Bluff.....	320,150	60.63
Horn's Ferry.....	365,330	69.19
Work's Landing.....	376,752	71.35
Wright's Landing.....	446,950	84.64
Yellow Bluff.....	536,352	101.53
Bearman's Bluff.....	605,168	114.61
Richardson's Bluff.....	676,866	125.19
Weiss Bluff.....	759,364	143.61
Plateller's Bluff.....	814,837	154.32
Bunn's Bluff.....	834,177	157.98
Beaumont.....	890,617	165.67
Smith's Mill.....	979,026	183.42
Remly's Mill.....	994,042	185.26
Mouth of river.....	1,032,483	195.56

The water being high during the survey of the whole river, some logs and snags may have escaped notice. This was especially unfavorable for the portion between Weiss Bluff and Bunn's Bluff.

This part being susceptible of low-water navigation, it would have been important to ascertain the character of the obstructions to low-water navigation.

The number of obstructions to navigation in the several parts of the river are as follows:

	Distances.	Overhanging Trees.	Snags	Logs	Rocks.
	<i>Miles.</i>				
From Boonville to the Angelina Junction.....	45.78	1,325	333	350	1
From the junction to Weiss Bluff.....	98.03	1,058	80	105	1
From Weiss Bluff to Bunn's Bluff.....	14.17	49	11	5	
From Bunn's Bluff to the mouth of the river.....	37.58	30	21	7	

IMPROVEMENTS.

The portion of the upper river between Boonville and the junction being in the same condition as the Angelina River, everything stated for the latter can be applied to this part, and the work should be done in the same way.

The rock mentioned in the previous description will have to be removed.

The portion of the upper river between the junction and Weiss Bluff should be treated in the same way as the Angelina River. There is a rock at a place located on the map which will have to be removed to low-water surface.

The portion of the lower river between Weiss Bluff and Bunn's Bluff being susceptible of low-water navigation, special attention should be given to this part in removing from the bottom of the channel all logs and snags which obstruct it and cause the formation of sand-bars as before stated.

With regard to the other portion of the lower river between Bunn's Bluff and Sabine Lake, nothing special is to be mentioned; cutting down some trees and removing a few snags and logs are the only things to be done.

MOUTH OF THE NICHES RIVER AND BAR.

The Niches River empties into Sabine Lake about four miles west of the mouth of Sabine River, and about twenty-six miles from Sabine Pass. It has a bar at its mouth where the water of the lake checks the velocity of the river-current; this bar is formed by the deposits of mud and sand that the river-water holds in suspension, which takes place as soon as the velocity is checked.

There are two passes or channels across this bar, indicated on the map by the broken lines A B and C D. It would appear that these passes are formed by two lateral currents, resulting from the division of the main current of the river, which is deflected by the middle ground in front. Pass A B is the one principally used. Pass C D, called East Pass, has less water, but is sometimes used by sloops of light draught, in case the wind does not permit of going through Pass A B.

Pass A B has once been dredged to a channel 60 feet wide and 5 feet deep, but is now smaller, owing to the filling in by the action of the waves across it.

The prevailing winds range between east and south and the storms blow generally from the southeast, thus, as will be seen by referring to the map, the waves breaking over the shallow place known as the "middle ground" between the two passes have a tendency to wash the sand into the channels, and thus reduce their depths.

According to the statements of some captains the channel A B has been reduced in depth as much as 18 inches during one storm. I think that its actual depth would be much less if it were not for the passage of steamboats, which often drag on the bottom, and by the action of their wheels deepen it.

During strong easterly winds, which frequently occur, steamboats have great difficulty in running through channel A B. They are liable to be drifted out of the channel onto the shoals to the west.

It often happens that vessels grounded in this way are detained for several days.

IMPROVEMENTS.

Two ways of improving the mouth of the river are to be recommended. First method, improving one of the passes; second method, making a new channel across the middle ground.

For the first method pass A B is to be preferred, since its course is the most direct to the deep water of the lake. This can be improved by closing the space between Doom's Island and the mainland; also to build a jetty from the point of this island across the inner end of the pass C D, and from there extending it all along the east side of pass A B to deep water. This jetty would confine the whole current of the river to pass A B; and, if a channel were once dredged to a required cross-section, this current would keep it open. It could be even expected that the jetty alone would cause the deepening of the pass by the scouring action of the increased current. It would also prevent the washing-in of the sand from the middle-ground.

The second method consists, first, in cutting a new channel, following the line E F, which is merely the extension of the center line of river-channel above the passes. It appears obvious that this is the natural course which the current would take were it not deflected by the middle-ground. Thus, by making a straight cut across it, the water would take this course. Secondly, in closing the space between Doom's Island and the mainland; also building a jetty from the point of this island across the inner end of the pass C D, and gently curved, to connect it with the northeast side of the cut, so as to direct the whole of the river-current into it, which would keep it to a constant depth. Some of the sand excavated could be used to fill the inner end of pass A B; and, in case this should not prevent the current running through this pass, a jetty would have to be built from there to the mainland, which, together with the one connected with the point of Doom's Island, would direct the whole current of the river through the new cut. The balance of the excavation should be put on each side of the cut, but especially on the northeast side. This would form a permanent embankment connected with the jetty, which would protect the channel from the action of the waves.

However, this channel, having a southeasterly course, would have the best possible location with regard to storms. The sea would roll in the direction of the axis of the channel, instead of diagonally across, as it does at pass A B.

The location of pass A B being unfavorable with regard to the strong easterly winds, as explained before, I would therefore recommend the second method, in case the additional benefit the navigation should derive from it would justify a somewhat greater expense than that necessary for the first.

The jetties proposed in either case are to consist of a single row of close-piling, with a cap; the piles to be of cypress timber, an abundance of which can be readily obtained up the river.

The water being fresh, such a jetty would remain for years.

ESTIMATE.

The dredging of pass A B to a channel 80 feet wide and 5 feet of water at mean low-tide, with its banks sloping one foot in two, would amount to 47,851 cubic yards of excavation; the length of the channel being 6,500 feet and the average depth of cut 2 feet.

Length of jetty from Doom's Island to channel.....	Feet. 2,500
Length of jetty along the channel.....	6,500
Total length of jetty.....	9,300

Second method, cut through middle-ground.

The channel having the same dimensions, length of cut being 6,500 feet, and the average depth 3 feet.

Cubic yards of excavation.....	Feet. 62,111
Length of jetty.....	2,500

Very respectfully,

A. DEMAN,
Assistant Engineer.

Lieut. H. M. ADAMS,
Corps of Engineers, U. S. A.

R 11.

SURVEY OF PASCAGOULA HARBOR, MISSISSIPPI.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., October 23, 1873.

GENERAL: In accordance with your instructions, contained in Engineer Department letter of March 19, 1873, and the project submitted in my letter of May 8, 1873, approved by you, I have had completed a survey of Pascagoula Harbor, in the State of Mississippi, and submit the following report thereon:

The survey was commenced July 10, 1873, by a field-party, under the direction of First Lieut. J. B. Quinn, Corps of Engineers, United States Army, (his report attached and made a portion of this,) and was completed August 6, 1873.

The plotting of field-work has just been completed, and the result is submitted herewith on one chart.

The survey had for its object the formation of a plan for improving the entrance to the river and harbor of Pascagoula.

The plan for this, presented by Lieutenant Quinn, meets my approval: also, his estimate of cost.

The estimate for concrete-covered gabions was based on cost of an experimental gabion made at Fort St. Philip.

An appropriation of \$30,000 is recommended for this work, its expenditure being made contingent on the State of Mississippi securing from the owners of Noyes Canal a release of all claims the latter might have against the United States, were the latter to proceed with works of improvement without such release. Without this precaution, the United States would place itself in the position of trespasser on the rights of an individual, secured by State charter, and become responsible for damage in a sum, which, owing to the indeterminate value of the right

(the question of further increase of value from presumed increase of commerce being a factor) might amount to double or treble the value of the work.

The appropriation of \$30,000 recommended conditionally, with \$25,000 appropriated by the State of Mississippi and \$5,000 by the people of Pascagoula, should complete the work, and leave a balance, perhaps, sufficient to purchase the rights of the canal company; this estimate, of course, assuming the State appropriation in cash.

Financial statement.

Allotted for survey from appropriation approved March 3, 1873.....	\$2,000 00
Expended on survey.....	492 11
Balance on hand, New Orleans.....	1,507 89

Particulars relating to location of work, nearest light-house, and commerce to be benefited, will be found in report and papers affixed hereto.

Very respectfully, your obedient servant,

C. W. HOWELL,
Captain of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Report of Lieut. James B. Quinn, Corps of Engineers.

NEW ORLEANS, LA., October 15, 1873.

SIR: In pursuance with your instructions, I have the honor to submit the following report upon the condition, with suggestions for improvement, of the entrance to the Pascagoula River, Mississippi.

The Pascagoula River empties into Mississippi Sound at a point about forty miles from Mobile and one hundred miles from New Orleans. A large portion of the State of Mississippi is drained by this river, and Dog River, one of its tributaries, reaches up into Alabama a distance of three or four hundred miles. Light-draught steamboats have been run to Enterprise, Mississippi, a distance of four hundred miles from the mouth of the Pascagoula, and it is estimated that the Pascagoula and its tributaries furnish thirteen hundred miles of navigable water.

The region traversed by these rivers contains immense forests of pine, cypress, cedar, poplar, oak, and other valuable timber, and extensive plains and bottom-lands, unsurpassed in fertility, and admirably located for the culture of almost any of the most valuable productions of the South.

Owing to the political constitution of this region previous to and the depressing circumstances attending the late war, its development has not been such as its favorable location and natural advantages would suggest; but during the past few years the lethargy which has enveloped this section has been gradually disappearing before the advance of an awakening spirit of enterprise, and rapid strides are now being made in those industries this section of the country is so admirable fitted to promote.

Naturally, the immense forests which border upon the Pascagoula and its tributaries first attracted the attention of capitalists, and at an early date several mills for the transformation of the magnificent pines of these into lumber were constructed. The ready market this lumber found soon established the value of this industry. Other mills were soon established, and this business has now grown to grand proportions, and ships lumber to Europe, South America, and distant countries, besides supplying a large portion of that required for home consumption.

The lumber-trade brought others in its train, and with each succeeding year the prospects for the future of this country grow brighter and brighter.

The climate is salubrious and very pleasant, the heat of midsummer being far from excessive; the Gulf breezes tempering the air in such a manner that persons even from

more northern latitudes can labor during the hot months as comfortably as in New York, and with as much surety of good health; in fact, the town of Pascagoula, at the mouth of Pascagoula River, is a famous southern watering-place, and during the summer-months is visited by numbers of people from Mobile, New Orleans, and other cities: this locality is singularly exempt from acute and febrile diseases, and northerners have no fears of spending the summer here.

During the year 1872, 64,500,000 feet of lumber was manufactured at Pascagoula, and it is not improbable this quantity may be exceeded this year. Most of this is shipped in light-draught schooners, that can come direct to the mills, the existence of a bar at the mouth of the Pascagoula preventing the passage of other vessels. Large vessels which come here for lumber lie at anchor in Mississippi Sound, about five miles from the mouth of the river, and the lumber is lightered out to them. This sound affords a secure anchorage for vessels drawing over 22 feet of water, but this is the limit of depth at the entrance to the sound between "Pétite Bois" and "Horn Island," and vessels drawing more than this would be unable to enter. As most of the shipments of lumber from this place are coastwise, the advantage of having a good channel across the bar at the mouth of the river was early apparent, and private capital was enlisted in procuring a channel to admit vessels drawing 6 feet of water at low-tide. A charter for this purpose was granted by the State of Mississippi to Abram A. Green on the 31st of January, 1869. (See copy attached, marked A.)

By this charter the owners of the canal were authorized to charge vessels passing out through the canal a toll of 30 cents per ton measurement, and this privilege of maintaining a canal, and collecting tolls from passing vessels at this place, was made exclusive for a period of twenty-five years, dating from the passage of the acts conferring the charter. At the expiration of twenty-five years, the canal and appurtenances thereof were to revert to the State of Mississippi.

This canal was finished on the 1st of March, 1870, and, as an inducement for small vessels to use it, a toll of 15 cents per ton was charged all vessels under fifty tons, and 10 cents per ton when lightering to vessels in the sound. (See letter attached, marked B.)

Previous to the construction of this canal the navigation at the mouth of the Pascagoula was confined to vessels of from thirty to thirty-five tons. At present vessels of from eighty to one hundred tons are able to ascend direct to the mills, and after loading proceed through the canal to sea without difficulty. This canal, known as "Noyes's Canal," was constructed by dredging a channel through the bar, depositing the material dredged on one side. No attempt to prevent the subsequent filling in, by revetting the sides of the canal, was made, and to preserve the requisite depth of water it has been found necessary to resort periodically to dredging.

The position of this canal is shown on the accompanying chart.

Though this tax, imposed upon the commerce using "Noyes's Canal," is insignificant compared with the very great advantages resulting from its use, the fierce rivalry existing between the different lumbering points on the Gulf coast renders even this a matter of considerable importance when successful competition in the domestic market is requisite, and is quite sufficient to throw the trade into the hands of those who have no such navigation tax to pay. Some measure having for its object the relief of the milling interests from this exaction is now greatly desired, and Government aid is solicited to assist in improving the natural channel at the mouth of the river.

In the event of this work being undertaken by the Government, it must result in the extinguishment of the private interests involved in the present canal, and subject the owners to considerable loss. Before the Government could, therefore, consistently engage in such an undertaking, the mistake made by the State of Mississippi, in sanctioning the construction by private parties of a similar work at this place, should be rectified.

From the letter annexed, marked C, it will be seen that an appropriation of \$25,000, in State bonds, was made by the State of Mississippi for the improvement of the mouth of the Pascagoula River; this grant was made conditional upon the actual expenditure of \$5,000 by the citizens of Pascagoula on the improvement. We are not informed as to the availability of these sums of money, or what efforts have been made to secure the State funds, or the method of improvement adopted by the State commissioners, further than that to be inferred from the following advertisement:

"Proposals for dredging the mouth of Pascagoula River."

"Whereas, at a meeting of the commissioners appointed by the State, held at East Pascagoula, Miss., on Monday, August 18, 1873, for the improvement and deepening of the mouth of said river, the secretary was authorized to advertise for sealed proposals for dredging the same at so much per yard. All bids must be sent in by September 29, 1873. The commissioners reserve the right to reject all bids.

"W. S. DODSON, Secretary."

"PASCAGOULA, MISS., August 27, 1873."

If dredging to improve the natural channel is resorted to, an injunction will be obtained by the canal company to restrain the commissioners from constructing a second canal, &c. Since no other system of improvement will answer the requirements of the situation, we are at liberty to infer that whenever the Government shall undertake the improvement of the entrance to the Pascagoula River the condition of affairs at present existing will be practically the same, and under this hypothesis the following project of improvement is submitted.

The obstruction at the mouth of the river consists of a bar, formed principally by the action of the river current, and a littoral current produced by the action of the prevalent winds; the locality may, for practical purposes, be considered as in a well-sheltered harbor, and therefore not subject to the violent action of the sea-waves.

The method of improvement proposed contemplates the cutting of a channel through this bar, and the protection of the cut by light jetties on both sides. The presence of the ship-worm in these waters excludes construction of timber, when it is exposed to their attacks; and, since this is about our only available material for this purpose in the present case, some device to insure its preservation becomes necessary. The ship-worm does not operate beneath the surface of the sand. It does not destroy small twigs and fibrous material.

The jetties are simply to arrest the littoral sand-currents, and will not be required to withstand any very great force from waves or currents.

The following construction will answer the requirements of the situation:

The jetties to be made by placing cement-covered gabions side by side, and filling them with the material dredged from the channel, the remainder of the excavated material to be thrown outside of these, thus forming an embankment of which the gabions will be the interior revetment.

Thus—

The gabions will prevent the embankment from being degraded, in a manner similar to brush-jetties in the formation of sand-dunes, and the cement covering to the wicker-work will prevent the sand from running out of them, and, while serving for ballast, will preserve the material from the action of the ship-worm.

The gabions are to have planked bottoms, and be strengthened by a timber-cross near the top.

The location of the jetties is indicated on the accompanying chart.

The cut through the bar to be 100 feet wide and of a depth sufficient to admit vessels drawing 7 feet of water at low tide.

ESTIMATED COST.

Eastern jetty, 3,500 feet long.....	\$8,750 00
Western jetty, 4,000 feet long	10,000 00
Contingencies	2,250 00

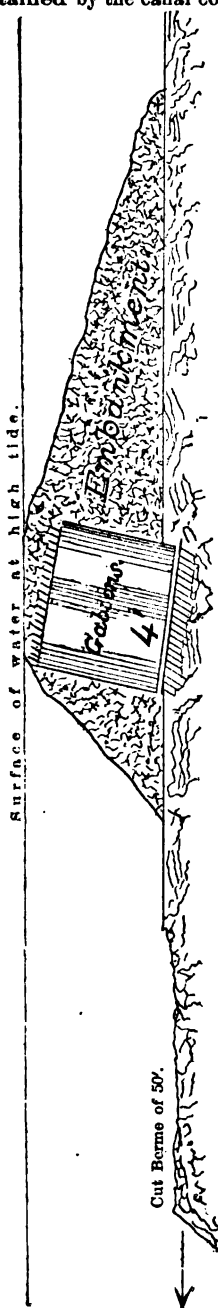
Total for jetties..... 21,000 00

Considerably less than a corresponding length of closer piling.

Dredging 38,862 cubic yards, at 50 cents per yard...	\$19,431 00
Contingencies.....	1,943 10

Total for dredging..... 21,374 10

Total cost of improvement 42,374 10



This estimate is based upon the supposition that the construction of the jetties and the dredging of the channel are conducted simultaneously.

This work is in the collection-district of Pearl River, and the nearest port of entry is Shieldsborough; the nearest light-house is the one at the mouth of the river.

Very respectfully, your obedient servant,

Capt. C. W. HOWELL,
Corps of Engineers, U. S. A.

JAMES B. QUINN,
First Lieutenant of Engineers.

A.

AN ACT to authorize Abram A. Green to cut or excavate a channel or canal through the shoal or shell-reef which now obstructs the navigation of the Pascagoula River.

SECTION 1. *Be it enacted by the legislature of the State of Mississippi*, That Abram A. Green be, and he is hereby, authorized to enter upon and take possession of so much of the shoal or shell-reef, situated at the mouth of the Pascagoula River, in the county of Jackson, as may be necessary to cut or excavate a channel or canal of sixty feet in width, and of sufficient depth to afford a good and safe passage at low-tide, to steamboats and other vessels drawing six feet of water, into and out of said Pascagoula River; and the said Green is authorized to build all such light-houses, beacons, wharves, and other buildings as may be necessary for the full attainment of the object of this act: *Provided*, That nothing in this act shall be so construed as to give said Green the right to obstruct or in any manner interfere with any channel now existing through said shoal or shell-reef.

SEC. 2. *Be it further enacted*, That so soon as the said Green shall have deepened or excavated a channel of sixty feet in width, and of sufficient depth to admit the passage, at low-tide, of steamboats and other vessels drawing six feet of water, he shall be authorized to charge and receive from all such boats and vessels as may go out of the said Pascagoula River, through said channel, a toll not to exceed thirty cents per ton, for every ton of the registered measurement of such boats and vessels; and any boat or vessel that shall become liable for toll as aforesaid, and whose captain, owner, or other persons who may be in charge, shall refuse or neglect to pay the same for five days, after the same shall have been demanded, shall be liable to be sued for the amount of toll due, together with fifty per cent. damages, and the said boats and other vessels, and their captains and owners, shall be liable for the same, together with costs of suit, to be collected before any court of competent jurisdiction: *Provided, however*, That suits for tolls may be instituted before the expiration of five days, if deemed advisable, and that said Green may prevent the passage of any boat or other vessel through the channel aforesaid until the tolls are settled: *And provided furthermore*, That all boats and vessels may go into the Pascagoula River through said channel without the payment of any toll or charge whatever.

SEC. 3. *And be it further enacted*, That said Green be, and he is hereby, invested with all the rights and powers necessary for the construction, repairs, and maintenance of said channel, and of the necessary wharves, buildings, light-houses, and buoys appurtenant thereto; and it is stipulated and agreed that for and during the term of twenty-five years from the passage of this act the said Green shall have and enjoy the exclusive right and privilege of constructing a channel or canal for the passage of steamboats, or other vessels, through the said shoal or shell-reef: *Provided*, That in case said work shall not be so far advanced at the end of eighteen months from the passage of this act as to admit of the passage at low-tide of vessels drawing six feet of water, then this act shall be null and void: *And provided further*, That at the end of twenty-five years from the completion of said work, the rights and privileges conferred by this act shall expire, and said work and its appurtenances shall revert to and become the property of the State of Mississippi.

SEC. 4. *Be it further enacted*, That the said Green shall have the right, and he is hereby authorized, to associate with him in the construction of said work such persons as he may see fit; and that at any time after he shall have so far completed said canal or channel as to admit the passage, at low-tide, of vessels drawing six feet water, he shall have the power to sell or convey any portion or all of the rights and privileges conferred upon him by this act.

SEC. 5. *Be it further enacted*, That should any person or persons, willfully or carelessly, do any act whereby said work shall be injured or impaired, or the navigation of the channel authorized by this act shall be obstructed, or whereby said Green or others interested in said work shall be hindered or disturbed in the prosecution or enjoyment of said work, such person or persons so offending shall be liable to a fine of \$500, to be sued for and recovered before any court of competent jurisdiction, and they shall also be liable to the proprietor or proprietors of said work for all damages which they may have caused to them by such act, to be sued for and recovered before any competent tribunal.

SEC. 6. *Be it further enacted*, That this act shall take effect and be in force from and after its passage.

Approved January 31, 1867.

B.

Letter of Superintendent and Collector of canal.

SCRANTON, MISS., September 8, 1873.

SIR: Your letter of the 4th instant is before me, asking information on the following questions:

1st. What was the condition of the commerce and navigation at East Pascagoula previous to the construction of "Noyes' Canal?"

I answer, "It was entirely confined to vessels of thirty and thirty-five tons."

2d. Has the construction of Noyes' Canal proved of any benefit to the commerce of Pascagoula River?

It certainly has; vessels now load at the mills above, of eighty to one hundred tons, and pass readily to sea through the canal; it has also developed the commerce of the place by enabling our mill-owners to contract to load large vessels outside, within a given time, and thus save demurrage.

3d. Give me the history of Noyes' Canal, with act of incorporation, charter, &c., and system of tolls charged.

Herewith inclosed find copy of the act of incorporation and charter, by which you will perceive they are allowed 30 cents per ton, register, of vessels using it.

In consequence of the natural channel, and to induce small vessels to use the canal, a less amount, or 15 cents per ton, has been charged all vessels under fifty tons each, and, when lightering to outer bay, only 10 cents per ton.

4th. What was the cost of construction, and annual cost of maintenance of canal, and what nature was the material removed in its construction?

On March 1, 1870, the canal was declared finished; it then had cost \$27,000. In consequence of repairs, redredging, &c., it has cost \$4,000 per year to maintain it. The material removed was mud, sand, and a hard blue clay.

Respectfully,

F. VAN WAGENEN,
Superintendent and Collector of Canal.

JAMES B. QUINN,
First Lieutenant United States Engineers.

C.

Letter of Mr. E. F. Griffin.

MOSS POINT, MISS., August 26, 1873.

DEAR SIR: Your letter of inquiry about the past and present condition of the lumber and miscellaneous commerce and future commercial prospects of East Pascagoula has been received.

Query 1. "Lumbering interests previous to the construction of Noyes's Canal."

The amount of lumber very little, if at all, exceeds that manufactured previous to its construction. The canal has had no appreciable effect on the lumbering interests; as, to within a few months, it has been but little better than the natural channel; it, seemingly, having been the object of the owners to merely do enough to keep the charter and collect the tolls from us.

At that time there was no foreign trade in lumber, our place being almost unknown, and the home-market being good, we were incapable of supplying the demand. After the domestic trade began to fail, of course the lumbermen began to seek other markets, and by furnishing lumber at lower prices than it could be obtained at other points, they succeeded in securing a considerable trade with other points.

Query 2. "Present condition of lumbering interest and obstacles to its advancement."

It is duller now than it has been for eight years, caused in domestic markets by the general depression of business and want of tonnage at reasonable figures to foreign ports.

Query 3. "Probable effects upon the commerce of East Pascagoula in the event of a channel 9 or 10 feet deep being cut through the bar at the mouth of the river."

Could not say to what extent, but would necessarily increase it very much, as a large portion of the lumber exported from here could be shipped on vessels drawing that amount of water, which could come direct to the mills and load, thus saving to the producer the lighterage, and thus direct from the Gulf and Atlantic ports to our own a large amount of trade, on account of facilities and prices in purchasing.

Query 4. "What efforts the State of Mississippi has made to secure a proper channel at the entrance of Pascagoula River."

The State has appropriated \$25,000, and the citizens \$5,000.

Query 5. "Agricultural prospects of the country which would probably make East Pascagoula its shipping-point, and the extent of country and nature of products"

As there is a charter for a railroad from the interior of the State to this point, when completed, together with the rivers tributary, the entire State could have an outlet for its various productions.

Very respectfully,

E. F. GRIFFIN.

Lient. JAMES B. QUINN,
United States Engineers.

Statement of official business at the port of Pascagoula, District of Pearl River, from July 1, 1872, to June 30, 1873.

Total entrances, foreign and do- mestic.	Total clearances, foreign and do- mestic.	Total tonnage.	Amount of duties collected.	Remarks.
97	141	45, 256. 26	\$125 30	Shieldsborough is the only port of entry in the district of Pearl River.

Respectfully submitted.

W. H. GILLESPIE,
Deputy Collector and Inspector.

R 12.

SURVEY AT ENTRANCE OF MATAGORDA BAY AND THE CHANNEL OF INDIANOLA, TEXAS.

WASHINGTON, D. C., February 4, 1874.

GENERAL: The survey of the entrance to Matagorda Bay and channel to Indianola, Texas, has been completed.

Mr. H. C. Ripley, assistant engineer, had charge of the field-work. He reports as follows:

Preparations for the survey were commenced August 1, 1873.

The "Fleetwing," a schooner of twenty-one tons burden, and of 3 feet draught, was chartered at Galveston, Texas, and a four-oared launch, belonging to the Department, being available, was also used.

The instruments used were two Gurley transits and two sextants: one made by Blunt of London, the other by Stuckpohl, of New York.

Everything being in readiness, we left Galveston on the 10th of the month, and arrived in Matagorda Bay on the 13th.

Two base-lines were measured: one at Indianola, between stations 1 and 2, and the other on Matagorda Island, between stations 14 and 15.

The computed length of the second base only differed from its measured length by $\frac{1}{16}$ foot in a distance of sixteen miles.

The soundings were located by means of two sextants, and locations were made as

often as one each minute where the depth was changing rapidly, but where it was comparatively even, as in the bay, locations were made about once in three minutes. Three tide-gauges were established: one at Indianola, on Morgan's wharf, (gauge No. 1,) one at the West Shoal light, just inside the pass, (gauge No. 2,) and the third on the point near the old light-house, (gauge No. 3.)

Gauge No. 3 was only kept while outside soundings were being taken; gauge No. 2 was kept during the whole time of the survey; and gauge No. 1 was kept until the soundings were finished.

The mean low-tide to which the soundings were reduced was obtained from the United States Coast Survey Office at Washington, and differs from the mean low-tide during the time of survey by 0.47 foot, and is lower by this amount.

A wind-record was also kept during the time of the survey by the United States signal observer at Indianola.

BORINGS.

Borings were carefully taken. Seven holes, varying in depth from 26½ to 53 feet, were made, and 32 specimens were preserved, all of which are properly labeled and left in the office.

An effort was made to reach the clay at borings E, F, and G, nearest the bar, but the driving was so hard (requiring as many as sixty blows with an eighty-pound hammer to the inch) that it was impossible to do so.

Below will be found a sketch (see original) showing the sections of the borings and the character of strata in each. A is at the outer end of Morgan's wharf. B is on the shore just below Powder Horn Bayou. C is at the Swash light. D is at the White or West Shoal light. E is on Decrow's Point. F is at the outer point of Pelican Island; and G is on the point near the old light-house.

It appears almost evident from an inspection of the three borings, one at either end of the bar, and one on Pelican Island, nearly out to the bar itself, that this bar, like the one at Galveston, is composed of pure quicksand to a depth of from forty to sixty feet.

CURRENTS.

It is necessary to remark that it was impossible to take the current-measurements at any uniform stage of the tide, and consequently it often appears that there is very little current at a certain position, when close by, at another position, there is a current two or three times as strong without any apparent cause.

The reason is that they were taken at different times and the actual velocity of each plotted. Reference to the tide and wind chart may tend to explain some of these differences and show what their relative velocities are.

But this will not answer in every case; for we found that some of the strongest ebb-tides occurred when the tide-gauge did not fall one-tenth of a foot for several hours.

I attempted to form a table showing what the velocity at certain places should be with a certain rate of fall or rise of the gauge, but I found that a rise or fall of one-tenth of a foot per hour one day would give scarcely any velocity to the tide, while at another time there would be a strong tide without any perceptible change in the gauge. I was, therefore, obliged to abandon the scheme.

The directions as shown on the chart, and the general character of the bottom and surroundings, will probably give a better idea of the relative velocities at different positions than anything short of a long series of observations.

CONCLUSIONS.

Matagorda Bay, from Indianola as far down as the old Swash light, has a very uniform depth. The bottom is generally covered with a deposit of soft mud, which at Indianola is five feet in thickness.

Below this point it comes under the influence of the pass and sand-bars, and deeper channels begin to appear, which are continually changing and shifting under the influence of the wind and tide.

At the mouth of the pass and on the bar we find a very marked change since the last Coast-Survey chart was made.

Pelican Island has moved north and approached Decrow's Point nearly its entire

width; thus making the Elizabeth channel more defined and deeper, and diminishing the distance from the island to Decrow's Point from 7,440 feet to 4,180 feet.

Red Fish Spit has made its appearance, and the large shoal extending from it has mostly formed within the last two years. The point just below the old light-house has but recently formed, and its development is progressing very rapidly; so much so that its growth was quite obvious during the time of the survey.

At a point where tide-gauge No. 3 was located, it made out not less than 75 feet in about two months.

Old Channel was the main channel for the entrance of vessels until August of the present year.

It was after the 13th of that month that the first vessel was brought through the Veto Channel by the pilots.

Now they do not venture to bring in even the smallest vessel through Old Channel, and if it is at all rough it is not safe to enter even with the pilot-boat.

At the time of the last coast survey, the Veto Channel was not in existence, and where there is now 24 feet of water there was then but 5 feet.

It is said that the origin of this channel is due to the fact that the schooner Veto was driven across the bar at this place during a violent storm.

Thus getting a start, it gradually deepened and widened until it became the main channel across the bar.

But we are led to seek other influences which might cause the water to leave its straight course down the old channel and turn abruptly to the southeast, as it does in following the Veto Channel.

The littoral current at this place flows in either direction, northeast or southwest; its direction apparently depending entirely upon the direction of the wind.

Let us see what effect this littoral current has on the water in the various channels:

At flood-tide there would be but little effect, probably not worth consideration, but at ebb-tide great changes are produced.

Let the littoral current be running southwest, as the water from Elizabeth Channel meets it, it is checked, and thus much of the water which would have gone out this channel is sent down to re-enforce Veto and Old channels.

As the water in Veto Channel meets the littoral current, it is little affected by it, since it meets it at right angles.

As the water from Old Channel meets it, it is assisted somewhat, since it flows nearly in the same direction,

Now let the littoral current run to the northeast. When the water from Old Channel meets it, it is checked abruptly, and Veto Channel receives a greater part of the water which otherwise would have gone out this channel; an eddy is formed, which is no doubt the cause of Red Fish Spit and the shoal near station 18, and which is now causing, since the opening of Veto Channel, an apparent closing of Old Channel altogether.

As Veto Channel meets the littoral current again at right angles, it has little or no effect upon it. With this direction of the littoral current, the water of Elizabeth Channel is assisted slightly to escape, as well as that of Decrow's Channel.

If this theory be correct, the Veto Channel is the only one in which its waters flow uninterrupted by the littoral current, and consequently should be the one of the greatest permanency, since all other channels are equally liable to be affected by wind. According to the testimony of the pilots, Old Channel always was treacherous, and never maintained that uniformity of depth on the bar that Veto Channel does, so that the facts go to substantiate our theory.

The city of Indianola is a place of about 1,400 inhabitants, and has a railroad extended into the interior as far as Cnoro, DeWitt County, a distance of about sixty miles.

The following is the commercial statement for the year ending August 31, 1872:

<i>Description of vessels.</i>	<i>Entered.</i>	<i>Number.</i>	<i>Tonnage.</i>
Steamers, (side-wheel).....	149	174, 270	
Sailing-vessels			
Brigs.....	2	586	
Schooners.....	91	13, 387	
Total.....	242	188, 453	
	<i>Cleared.</i>		
Steamers, (side-wheel).....	149	170, 062	
Sailing-vessels			
Brigs.....	3	945	
Schooners.....	101	15, 399	
Total.....	253	186, 396	

Many vessels arrive at this port with lumber, &c., and depart with commodities the growth and produce of this State, that are not embraced in the returns of the custom-house, as such vessels, according to the revenue-laws, are not obliged to enter and clear.

CUSTOM-HOUSE STATISTICS.

Imports—coastwise.

Lumber, feet	5,808,000
Shingles	2,750,000

Exports—coastwise.

Animals, (number of head)	27,461
Cotton, (bales)	11,549
Hides, (number of pieces)	330,875
Wool, (bags or bales)	3,234

Imports—foreign.

<i>Commodities.</i>	<i>Quantity.</i>	<i>Value.</i>
Corn, (bushels)	29,383	\$34,294
Wheat, (bushels)	7,549	10,686
Sugar, (pounds)	57,777	4,203
Wool, (pounds)	108,080	10,937
Hides, (number)	5,597	22,383

Exports—foreign.

	<i>Bales.</i>	<i>Pounds.</i>	<i>Value.</i>
Cotton	782	414,331	\$58,658

The foregoing extracts indicate the difficulties to be met in attempts to improve this entrance to Indianola Harbor.

They are found in the unstable character of the bar and shore formations and in the great width and exposure of the entrance.

It is evident that improvement by dredging cannot be expected, and that to effect any measure of good we must resort to piers and training-works to direct the tide-currents in and out of Matagorda Bay and to concentrate them on the bar.

For works of this kind it is only deemed possible to submit a general plan, with suggestions as to its probable effects.

Should the work ever be attempted, the engineer in charge will undoubtedly, in the course of construction, find frequent cause for change, not only in the location and direction of his works, but also in details and modes of construction.

The first work recommended is the closure of Decrow and Elizabeth channels by inducing the formation of a shoal along the line X Y and the extension of Matagorda Peninsula to include Pelican Island. By this the probable changes effected in the shore-lines, it is thought, will be about as indicated by the dotted blue line, (thus, ...) The breakers (marked D in red) will probably extend outward on the line D E, leaving between that and Y a channel similar to the Elizabeth. The Veto Channel will be driven southward and the old channel obliterated by the movement of Red Fish Spit and Breakers. The depth across the bar will be increased perhaps to twelve feet.

These changes effected as indicated, the improvement may be continued by further contracting the entrance by the formation of shoals on the lines Y E and Z B. These formations, it is thought, will so direct and concentrate the tide-currents on the bar as to insure a single channel across with a depth of 18 or 20 feet and a width of from 500 to 1,000 feet.

▮ The same kind of structure as recommended in my recent report for Galveston Harbor and entrance will be applicable at this place.

Adopting this for estimate, the following results, viz :

STRUCTURE X Y.

Length	8,600 feet.
Assuming average height	12 feet.
Number of concrete-covered gabions required	7,165

ESTIMATE.

7,165 gabions, at \$30	\$214,950 00
Filling ditto, 45,378 cubic yards of sand, at 50 cents per cubic yard	27,639 00
Total	242,639 00
Add for machinery, buildings, floats, management, and contingencies, 20 per cent.	48,538 00
Total cost	291,167 00

As the depth of channel this is designed to give will be greater than the depth available through Matagorda Bay to the wharves at the city of Indianola, further improvement can only be considered desirable to afford a harbor near the point marked on the chart "Saluria."

To make the deep anchorage at this point available the structures Y E and Z B must be provided.

These constructed and estimated as for X Y give the following :

Y E—Length	6,800 feet.
Z B—Length	6,000 feet.
Y E—Number of gabions	5,665
Z B—Gabions	5,000
Total number of gabions	10,000

ESTIMATE.

10,665 gabions, at \$30	\$319,950
Filling gabions, 67,545 cubic yards, at 50 cents	33,515
Total	353,465
Add contingencies, &c., 20 per cent.	70,633
Total cost	424,153

It should be remarked that the character of foundation offered for these works does not admit of an attempt to make accurate estimates, and that, in consequence, those submitted have been made for a uniform depth of 12 feet, with no allowance for the shoaler places crossed by the structures proposed. It is thought but prudent to follow this course, which adds a large amount for contingencies over and above the 20 per cent. allowed.

CONSIDERATION OF THE PLAN.

Pass Cavallo forms the connection between the Gulf of Mexico and a large inland basin comprising Matagorda Bay, Espiritu Santo Bay, San Antonio Bay, and numerous smaller bays further inland, and connecting with these.

The approximate total area of the basin is five hundred and twenty square miles.

The water-level in this basin is daily raised and lowered by the Gulf tides, aided by the winds, and this produces daily a strong ebb and flood current through Pass Cavallo, creating in the contracted portion of the pass a deep-water way. When the width of the pass is 8,000 feet, the depth of channel is 25 feet and over for a width of about 500

feet. Passing this section the pass begins to expand and shoal until when reaching the Gulf the width has increased to 20,000 feet, and the depth of channel decreased to 7 feet. It is certain that by decreasing this width we shall gain increase of depth.

By the structure X Y we decrease it by 8,600 feet. By the further construction of Y E and Z B we reduce the area of discharge to, approximately, what it is, where there is now a channel 25 feet deep. It is fair to presume that this contraction will give a channel of at least 18 or 20 feet in depth.

As at Galveston, all the silt brought down by the small streams emptying into this basin is deposited before reaching the Gulf.

The wind-record, submitted with the Galveston report, may be taken as substantially the record for the same time at Pass Cavallo, and in considering the effect of winds on the tide-currents, the remarks for the one place will apply to the other. It is only important to observe that the axis of Pass Cavallo is nearly in the direction of the prevailing winds, (from the south and southeast,) and that the winds from the northward, from the peculiar funnel-shape presented by Matagorda Bay and Pass Cavallo, must have a vastly greater and beneficial effect when the pass is contracted than they are known to have on Galveston Bar.

The short time allotted for the field-work of the survey was not enough for a valuable wind or tide record, and barely enough for getting a sufficient number of current observations to show the general directions of the currents. This latter is, however, better shown by the contour of the bottom of the pass.

The velocity of the currents being dependent on ever-varying factors, velocity measurements can be of no use unless continued daily for perhaps a whole year or even a series of years. None are submitted.

In regard to the commercial importance of the improvement suggested, reference is made to statistics submitted.

Pass Cavallo is located in the collection-district of Indianola, Texas, and near Matagorda light-house.

Very respectfully, your obedient servant,

C. W. HOWELL,
Captain of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Inclosures: 1 chart of survey; 1 tracing survey of 1871; 1 tracing survey of U. S. C. S. Chart No. 107.

R 13.

SURVEY AT BAYOU LAFOURCHIE, LOUISIANA, FROM LAFOURCHE CROSSING TO THE MOUTH.

This survey was authorized by act of Congress approved March 3, 1873.

The report of the assistant engineer charged with the work and the chart accompanying it are respectfully submitted.

Report of Mr. R. B. Talfor, Assistant Engineer.

CAPTAIN: Having completed, in accordance with your instructions, a survey and examination of Bayou Lafourche, La., I have the honor to submit the following report of operations and results obtained:

With a party organized in New Orleans, I left that city December 6, 1873, for Donaldsonville, at the head of the bayou. At this point a flat-boat had been prepared for the use of the survey, but it being in some respects incomplete, delayed commencement of the work until the 15th of December.

On the 15th the field-work was commenced at Donaldsonville, and continued, with some interruption from bad weather, and two days' delay at Lafourche Crossing for supplies, until February 6, 1874, when it was completed at the Gulf of Mexico.

After waiting at this point several days for a boat on which to return to New Orleans with my party and the property belonging to the survey, and failing to get one, I was obliged to abandon the greater part of the property and return up the bayou in skiffs to the railroad-crossing, arriving in New Orleans on the 20th of February.

The chart of the survey was completed June 30, with tracing and this report.

CHARACTER OF SURVEY.

The bayou was meandered throughout its whole length with transit and stadia, and the work checked by triangulation across bends and to prominent objects at a distance from the banks of the stream.

The micrometer was frequently tested on lines measured with a steel tape, and found to have retained its adjustment perfectly.

Stations were selected at distances apart not exceeding 500 yards, and great care observed in reading both from the horizontal limb of the transit and from the stadia rods.

The work plotted remarkably well, showing but unimportant errors in the stadia measurements.

The line was also run by compass, but the needle being sluggish this was only used for determining magnetic variation at several points, and even these determinations may not be considered exact.

Soundings were made throughout the bayou, but only those indicating bars located. The bayou being at a high stage, but few obstructions to navigation were visible.

The approximate positions of many low-water obstructions were pointed out by planters and boatmen, and their character described.

Three hundred and eighteen cross-sections of the bayou were made, of which 64 are represented on the chart.

COMMERCE.

There were but two river steamboats regularly engaged during the past year in the navigation of the bayou, viz, the Henry Tete, with a carrying capacity of 1,000 hogsheads of sugar, and the Lizzie Hopkins, with capacity for 700.

At high-water the whole bayou is navigable for these boats. For about eight months in the year it is navigable for them to Thibodeauxville; for the remaining four months navigation for this class of boats is suspended by bars, snags, and stumps.

During the whole year the bayou is navigable for flats and luggers, but below Thibodeauxville, and especially from Raceland to about three miles below the State cut-off, there are points at which, during low-water, these are embarrassed by islands, batture, and snags, the luggers being obliged to lower sails and cordelle.

From Raceland a line of flat-boats make daily trips to Lockport, seven and a half miles below, and semi-weekly trips to the cut-off, twenty-two and a quarter miles below.

From Thibodeauxville to Donaldsonville, during the low-water season, (which usually lasts from August to December,) 16 flat-boats are engaged in the carrying trade, and it is reported that they are frequently obliged to unload to get over the bars.

This, if true, shows not only the importance of the bayou to the planters along its banks as a highway to their market, but also indicates the very shoal condition of the bars at low-water.

The low-water depths over these bars, and their lengths, I have not been able to ascertain with sufficient accuracy to warrant close estimates for deepening channels across them by dredging. This data can only be obtained by examination during low-water.

Those in the upper bayou were so obscure at the time of survey that I did not find them, and it is probable that they are only developed during low-water, the cross-sections showing very uniform during high-water.

From such information as I could get I have prepared the following table, and located

the bars on the chart, numbering them with the wrecks in the bayou, from Donaldsonville down to Lockport:

No.	Length.	Depth.	Locality.
1	-----	-----	At head of bayou.
2	50	2½	
3	100	2½	Nolan's plantation.
4	150	2	Lemmon's plantation.
5	-----	-----	Wreck of steamer Blue-Bird, right bank.
6	-----	-----	Wreck of flat-boat.
7	175	2	
8	60	2½	
9	90	2½	
10	-----	-----	Sunken flat-boat.
11	-----	-----	Wreck of steamer Anna Wagley.
12	-----	-----	Sunken flat-boat.
13	30	2½	
14	300	2	
15	125	2½	
16	-----	-----	Sunken flat-boat.
17	-----	-----	Wreck of steamboat at Lockport.

Nos. 1, 6, 11, and 16 were accurately located, the others approximately from information.

Below Raceland, as far as the "cut-off," the contraction and filling of the bayou is shown by the cross-sections on chart.

Commencing about three miles below the "cut-off" the bayou resumes its regular cross-section and there are no obstructions to the Gulf.

The planters claim that the gradual filling in of the bayou, from Raceland to the "cut-off," has created the necessity of almost annually raising their levees.

It appears that the crevasses of Bayou Lafourche have all occurred along this section, and so great is the belief of the planters interested that these are due to this gradual and natural damming of the bayou, that they expect each flood a crevasse on one side or the other of the bayou at some point of the section. To prevent artificial crevasses, that would relieve one side at the expense of the other, it is reported that during flood both banks are patrolled by armed men; those on the east bank to prevent their neighbors across the stream from cutting the east levees, and *vice versa*.

It is generally claimed that if this gorge of some twenty-eight miles in length be relieved by removing snags, and widening and deepening the channel by dredging, danger of crevasses would be avoided. Also, that navigation would be extended to the mouth of the bayou, for steamboats now in the trade, the full season; these now run to Thibodeauxville. Above the latter place it is claimed that dredging and the removal of a few wrecks and snags will give navigation for such steamboats the year round.

I submit the following approximate estimate for work of this character to give a 3-foot channel for the whole year:

Between Donaldsonville and Thibodeauxville.

9 bars, 4,000 cubic yards, at 50 cents	\$2, 000
5 wrecks, at average of \$800	4, 000

Between Thibodeauxville and Parr's Canal, (forty-two miles.)

Widening and deepening 150,000 cubic yards, at 50 cents	75, 000
500 stumps and snags, (about,) at \$20	10, 000
Add for contingencies 10 per cent	9, 100
Total	100, 100

The following statistics of the commerce to be benefited will indicate if the expenditure be warranted or not:

Agricultural statistics of Assumption and Lafourche Parishes, furnished by P. P. Griswold, residing at Thibodeauxville, Bayou Lafourche, La.

Parish.	Year.	Sugar, hogheads.	Number of pounds.	Value at 8 cents per pound.	Molasses, gallons.
Assumption	1870-'71	15,000	17,250,000	\$1,380,000	1,042 11-
Do	1872-'73	10,715	12,622,250	1,009,780	92,300
Lafourche	1871	10,000	11,500,000	920,000	700,000
Do	1872	13,000	14,950,000	1,196,000	990,000
Do	1873	6,000	6,900,000	552,000	40,000

Parish.	Year.	Value at 50 cents per gallon.	Barrels of rice, 200 pounds each.	Value at 6 cents per pound.	Total value of produc- tions.
Assumption	1870-'71	\$521,059	40	\$480	\$1,901.539
Do	1872-'73	46,180			1,053,900
Lafourche	1871	350,000	10,000	120,000	1,320,000
Do	1872	460,000	15,000	180,000	1,836,000
Do	1873	200,000	20,000	240,000	992,000

In addition to the above the oyster-trade amounts to about \$25,000 per annum, the greatest number going to New Orleans via Haring's and the company's canal. Oranges net from ten to twenty thousand dollars per annum. Corn is raised sufficient for home consumption—none for export. Irish potatoes approximate 12,000 bushels at an average of 50 cents per bushel. During the winter season several thousand dollars' worth of wild-duck are killed on the Lower Lafourche and shipped to New Orleans. Immense quantities of eggs and chickens are shipped all the year round—ten thousand, or more, dozen weekly.

There is another proposition for improvement, viz:

The construction of a lock at the head of Bayou Lafourche and the conversion of the bayou into a tide-water canal.

By your direction I did not run a line of levels down the bayou, and can therefore make no estimates for this.

All other information required is to be found on the chart.

Very respectfully, your obedient servant,

R. B. TALFOR,
Assistant Engineer.

Capt. C. W. HOWELL,
Corps of Engineers, U. S. A.

The navigation of the Lafourche derives its importance principally from the sugar-cane and rice plantations which line its banks from the Mississippi River to the salt marsh bordering the Gulf.

The amount and value of the products of these plantations are shown by the statistics presented by Mr. Talfor.

These products must be carried to find their market in New Orleans, via the bayou, either to the Mississippi River at Donaldsonville, or to Morgan's Texas and Louisiana Railroad at Raceland or Lafourche crossing, or through several canals leading from the Lafourche to the Mississippi. The rice-crop, which is principally grown on the lower portions of the bayou, is ready for market usually about the first portion of the low-water season. The cane-crop of sugar and molasses is ready for market from about the middle to the latter portion of this season.

Many of the planters, from a lack of capital on which to hold their crops, are forced to market them as soon as prepared for market. This occurs at a season of the year when the bayou is unnavigable for steamboats.

Flat-boat navigation, expensive, necessitating transfer either at Donaldsonville or at the railroad stations, and, at extreme low-water, often necessitating portage around bars, is then the principal dependence of

those planters who are obliged to realize on their crops as soon as harvested.

From these people there is a call for improved low-water navigation—for improvement to admit steamboats from the Mississippi River at low-water, or at least to facilitate flat-boat navigation.

The sugar-planters are not so oppressed as the rice-planters, for their crops are harvested later, nearer the time of the annual winter rise in the Mississippi, which restores navigation in the upper bayou.

The rice-planters occupying the lower bayou do not usually harvest until after the flood—which makes their portion of the bayou navigable—has passed.

These facts, aside from the general desire for improvement, coupled with another I will presently state, have created a diversity of opinion among planters of the upper and lower bayou as to the best means to be adopted for improvement.

The other fact is this. The bayou, instead of gorging at its head or its mouth, in the manner such outlets of the river usually become choked, and cease to be outlets from the river, is gorging along its middle section; that is to say, about midway between the river and the Gulf. This gorging has been effected by the lodgment of drift, principally in the shape of snags, the formation of islands and of batture. This gorging, according to the best information I could obtain, has been gradual, and its effect has been to, year after year, raise the water surface in the bayou above, during floods necessitating a corresponding increase in height of levees, or, in default of this, crevasses along the middle section, to the great injury of the rice-planters.

Prof. C. G. Forshey informs me that at Lockport, on this section, in 1851, the levees were but four feet in height, whereas now they are twelve feet high.

The planters on the upper bayou, who are least affected by this engorgement, and who have steamboat navigation for the greater portion of the season during which they most need it, think that the bayou should be left open at its head, and improvement made by dredging bars and removing snags, so as to lengthen their season of navigation.

The planters on the lower bayou, who rarely have steamboat navigation, and, when they do have it, only at a season when their crops are not ready for market, favor closing the bayou at its head, to thus save them from the expense of continually raising their levees and guarding them, even by force of arms, from overflow.

There are two compromise propositions: the one to convert the bayou into a canal, by closing it at its head with a lock and dam; the other to relieve the gorge along its middle section by removing the prime cause of this gorge, viz, the snags.

Let us consider the several methods of improvement suggested in the order they have been named.

No. 1 would involve the work and expenditure for which Mr. Talfor has estimated. The bars above Thibodauxville would require dredging every year to keep them down.

No. 2 would, for all seasons of the year, render worthless for purposes of navigation all the upper portion of the bayou, except at great expense for dredging. This is evident from the fact stated by Humphreys and Abbot, that at dead low-water the water surface at the head of the bayou is only $1\frac{1}{2}$ feet above mean low-water in the Gulf.

Cut off the river supply from the bayou and the bayou surface throughout its entire length would be reduced to the Gulf levee-bars, that now, at extreme low-water in the river, give from two to two and a half feet,

would then only give, the year around, from a half to one foot, except after dredging.

With dredging, a transfer to river or rail would yet be necessary. The plan would relieve the rice-planters from fear of inundation, except from crevasses in the levees of the Mississippi; it would do away with the expense of keeping up the Lafourche levees. It would not, at reasonable expense, give better facilities to the rice-planters for reaching their market. It would give the sugar-planters poorer, and besides cut them off from their present facilities for laying in their supplies of fuel, (coal,) an important item of sugar-house consumption, now laid in for the season during the period of high-water.

No. 3. A lock and dam at the head of the bayou would have the same effect as a solid dam. It would make the bayou navigation dependent on tide-water. It would call for the same amount of dredging as the second project, and in addition the cost of a lock with about a 20-foot lift.

The dredging could be dispensed with by using two locks, one at Donaldsonville and one about Thibodauxville, but it is evident the commerce will not warrant such constructions, when it is considered that these locks must be of a width to admit a steamboat, and of a length to admit a coal-boat, viz, 38 feet wide and 200 feet long. The cost, however, is not the most important objection. The head of the bayou is located below a sharp bend in the Mississippi, at a point favorable for silting up by the eddy below the bend, as is evidenced by past effects of low-water on the bar at the head of the bayou. That a channel of any kind is now maintained across this bar is due to the current over it. Cut this off and the head would entirely silt up each season, and continual dredging each year would be required to keep a way open to the upper lock.

The working expense of an ordinary dredge is about \$20,000 per year. Add to this the first cost of dredge, cost of renewal every ten years and cost of locks, it is evident why I did not choose to spend money in elaborating a plan for slack-water navigation of the bayou.

The fourth plan is recommended for two reasons:

1st. It will improve the navigation of the lower bayou so as to permit steamboats to run there at flood and a portion of the medium stages of the river. It will benefit flat-boat navigation for the whole year.

2d. It may relieve the gorge in this section of the bayou, and thus for a time relieve the planters from the necessity of raising their levees or of suffering from crevasses.

This, however, I simply put forward as a possibility.

For the work of improvement I recommend, I present the following estimate:

For removing stumps and snags in Bayou Lafourche, between Thibodauxville and Parr's Canal.....	\$10,000 00
--	-------------

I think the improvement recommended will be of but temporary benefit, for the reason that such evidence as we have shows the bayou to be gradually closing. Its ultimate closure, if left to the action of natural causes, I consider certain. When the planters of the Lafourche are given other roads to market, if the Lafourche be not before closed by nature, I would then advise its closure by a levee at its head, as set forth in the second proposition. This can be done after railroad connection is made along the bayou from Donaldsonville to Lafourche crossing, and can meet with but one objection, (which I will not dis-

cuss,) viz, the objection to closure of outlets of the Mississippi River, based on the fact that such outlets modify the action of floods in the river below them. It may be well, however, to state that Bayou Lafourche carries off from the Mississippi but a comparatively insignificant volume of water, and has never been looked upon as an important waste weir, like the Atchafalaya or Bayou Plaquemine, before its closure.

In my report on survey for "connecting the inland waters along the margin of the Gulf of Mexico, from Donaldsonville, La., to the Rio Grande River in Texas," &c., &c., I will treat at greater length the plan for locks at the head of Bayou Lafourche and slack-water navigation in the upper bayou.

The work I have recommended lies in the collection district of New Orleans.

The nearest light-houses are those at the mouth of the Mississippi and at the entrance to Atchafalaya Bay.

R 14.

SURVEY FROM MOUTH OF RED RIVER DOWN ATCHAFALAYA RIVER TO BRASHEAR, IN LOUISIANA.

This survey was authorized by act of Congress, approved March 3, 1873, and has been completed by Mr. F. P. Leavenworth, assistant engineer.

The following is his report :

NEW ORLEANS, LA., *June 30, 1874.*

MAJOR: I have the honor to submit the following report of the survey of the Atchafalaya, made under your direction, from December 23, 1873, to April, 1874.

A suitable flat having been built and equipped at New Orleans, I started, December 23, in tow of the tug Neafie, with my assistant, Mr. W. A. Langhorn, and a party of seven, arriving at the mouth of the Atchafalaya at 9 o'clock a. m., on the 26th December.

A base line of 1,800 feet was measured on the eastern bank, micrometer adjusted, and some work done on the Atchafalaya before returning to Red River landing, whence a shore-line was run along the level, touching the bank of Old River, at the third mile, and reaching the initial point on the Atchafalaya at the sixth mile. Thence, a continuous line was carried down the Atchafalaya, stopping at Courtableau, (sixty miles,) to examine the Little Devil Bar, at Cow Island, (seventy-eight miles,) to run the Grand River Channel into Osca Bay, and the mouths of the Tensas, and at Bayou Boutte, (one hundred and twenty-nine miles,) to cross Grand Lake and run down the Old Atchafalaya to the Teche, (three and one-fourth miles,) where a connection was made with Mr. Hayward's canal-survey. Total number of miles of line run, 150½; total number of instrumental positions, 721.

Brashear City, (137½ miles,) was reached March 21, 1874, and the party discharged at New Orleans, March 27.

The following tabular statement shows the condition of the stream during the period of this examination :

Distance from Red River wharf-boat.	Width of stream.	Depth of channel.	Remarks.
<i>Miles.</i>	<i>Feet.</i>	<i>Feet.</i>	
3¼	2,342	24	Old River.
6	2,034	59	Old River.
6 m. + 790 feet.	891	114	Mouth Atchafalaya.
6 m. + 2,490 feet.	774	51	Atchafalaya.
7	750	45	Above Courville.
7½	720	36	Bayou Courville.
9	925	40	
11	870	28	Simmsport.
14	938		Fletcher's.

Distance from Red River wharf-boat.	Width of stream.	Depth of channel.	Remarks.
<i>Miles.</i>	<i>Feet.</i>	<i>Feet.</i>	
18	1,830	36	Hebberwick's.
23	995	28	Turner's Bayou.
26	720	41	
29	614	41	Gordon's.
30	713		Bayou Current.
34	792	38	W. C. Gordon's.
36	720	40	Churchville P. O.
39	668	39	Cow Head Bayou.
41	569	37	
43	627	51	
45	715	43	Wiltzie's Island.
47	458	54	Carmichael's.
50	419	51	N. Park's.
52	690	49	Near Alabama B.
54	345	48	L. M. Powell's.
56	415	54	Big Raw Bayou.
58	358	48	B. Servant's.
60	452	42	Mouth B. Courtableau.
63	329	42	
67	245	45	Bayou Alabama.
74	270	54	
77	408	52	Butte La Rose.
78	192	26	Little Atchafalaya.
78	501	48	Grand River.
81	187	30	Little Atchafalaya.
82	690	44	Hickman's.
84	428	38	N. O., Mobile & Texas R. R.
86	638	20	
88	412.	22	Ozanne Verret's.
89	598	7	Lake Mongoulois.
91	2,000	22	Lake Mongoulois.
93	510	36	Bayou Chêne.
95	212	39	E. Carline's.
96	440	20	Jake's Bayou.
97	1,800	9	Lake Chicot.
99	2½ miles.	6	Lake Chicot.
101	500	39	Chicot Pass.
104	442	8	Turkey I. Pass.
104	1½ miles.	12	Grand Lake.
120	9,630	9	Boutte Bay.
123	1,053	28	Cypress I. Pass.
123½	75	5	"Sunken Island."
130	4,290	52	Grand Lake.
133	1,838	64	Berwick's Bay.
134	1,458	74	Berwick's Bay.
135½	1,937	70	Berwick's Bay.
137	1,794		Berwick's Bay.
137½	1,853.03	74	Morgan's Depot, Brashear to Berwick.

The Atchafalaya River or Bayou, the largest waste-weir of the Mississippi, leaves the old channel of that river three hundred and ten miles above the Gulf of Mexico, in latitude north $31^{\circ} 00' 30''$, longitude west $14^{\circ} 41' 23''$, about two and one-half miles below the mouth of Red River, the entire ordinary flow of which it carries off, as well as a large portion of the Mississippi, when that river is at a high stage.

The course of the Atchafalaya is southwardly. Its length to the Gulf is one hundred and fifty-six miles.

At its source the average surface-width is about 780 feet, the depth 100 feet, and the discharge, (measured December 29, 1873,) 122,000 cubic feet per second; the velocity of a submerged float being 294.69 feet per minute.

A clay bar projects obliquely in a northwesterly direction across the source, spurs of which are touched in sounding 75 feet below the general level, in a section where the maximum depth is 114 feet.

The meeting of the waters of the Red and Mississippi Rivers, in front of the Atchafalaya, (December 29, 1873,) was marked by a foamy line of whirling drift, that separated the red from the clouded water.

The southern end of this line extended several hundred feet into the Atchafalaya, near the end of the base-line, giving the Red River water four-fifths of the channel at the mouth.

Since 1846 fears have been entertained that the mouth of Old River would close. Such a result might be apprehended if the Mississippi River were not so powerful an agent.

After the waters of Red River, rising before the Mississippi, have occupied the bend of Old River and mouth of Atchafalaya, a bar consequently forms in the dead-waters of Old River back to the mouth, and remains as long as the Mississippi is at a low stage; but when the Mississippi is in flood of greater height and longer duration than that of the Red River, all such obstructions are rapidly cut away, and all of the section of the Atchafalaya not occupied by Red River water is filled with the surplus of the Mississippi.

The surface-soil of the west bank is identical with the chocolate or maroon-colored mud of Red River; the eastern bank has an upper stratum of sand and whitish clay.

The land on either bank, below the mouth of Bayou De Glaize, being protected by substantial levees, is in a high state of cultivation as far down as Cow-Head Bayou, in the thirty-ninth mile, below which point there are no reliable levees. Some of the bayous closed by the State in this line of levees were wide and capable of carrying an immense amount of water; Turner's, Harvey's, Current, and three smaller ones, closed in 1870, have an aggregate section of 35,650 feet. The closing of these outlet bayous, thirty-seven in number on either side, has caused the river to scour its bed, deepening and widening it everywhere. This process has been gradual, and the present levees constitute the third system that has partially survived the caving of the banks, consequent upon the increased slope and velocity of current.

This is illustrated by a comparison of Dunbar's soundings in 1839 with those of this survey.

Below the terminus of the levees the Atchafalaya, no longer subject to control, spreads over low banks and is diverted into numerous bayous. Its width is narrowed down to 414 feet in the forty-sixth mile, although the average depth exceeds 40 feet.

Settlements are scarce and improvements of a poor and cheap quality. In the fifty-third mile the river divides, and the left fork, called Alabama, has a width of 307 feet and a depth of 24 feet. This bayou returns at the sixty-seventh mile, having a width of 178 feet. In the sixtieth mile, Bayou Courtableau, a navigable outlet about eighty miles long, having a width of 188 feet, a depth of 28 feet, and a section of 2,670 feet, flows to the west, connecting with the Teche and other confluent to the lakes and Berwick's Bay. At Butte La Rose, in the seventy-seventh mile, the outlet of some large lakes enters from the west, this point being near the foot of the steepest slope in the Atchafalaya basin.

The live-oak makes its first appearance a few miles above. The flood-marks of July, 1867, at this point were 10.08 feet above the water-level of February 6, 1874. The river here divides into two navigable channels; the left, Grand River, 605 feet wide, 50 feet deep, with a velocity of 177 feet per minute. The right-hand chute, "Little Atchafalaya," averages 190 feet in width, and 30 in depth.

At the eighty-first mile Bayou La Raurpe returns from Grand River to the Atchafalaya, 310 feet wide, 48 feet deep, with a velocity of 339.50 feet per minute. Grand River runs through the foot of Osca Lake, shallowing in one mile from 50 to 15 feet. Beyond the lake its width is 650 feet, depth 35, until it has poured its water into the seven Tensas bayous which flow southwardly into Lake Mongoulois. The first and seventh Tensas bayous are favorite low-water routes with the boatmen of lumber-tugs, and the latter may prove the best route in the future, avoiding Lake Mongoulois, and going by Jake's and Rigaby's Bayous to Lake Chicot. At the eighty-fourth mile, the line of the New Orleans, Mobile and Texas Railroad, ninety-five miles from Westwego, crosses the river 428 feet wide, 38 feet deep. A drawbridge is proposed here. Three miles below, a navigable channel, 298 feet wide, 24 feet deep, 750 feet long, turns to the left into Tensas Bay. The waters are now rapidly diverted on either side.

Five outlets pour to the right, and the stream narrows just below the eighty-eighth mile to 175 feet, the depth shoaling to 12 feet. A mile below the banks are low willow marshes; the width is 598 feet, depth 7 feet.

The shallowest water is in the first half of the ninetieth mile, where the right bank ceases and the Atchafalaya debouches into Lake Mongoulois. Below this point the depth averages 12 feet. At the ninety-second mile the channel enters Bayou Chêne, 500 feet in width. This divides, right into Crook Chêne and left into Jake's Bayou, leaving the stream 262 feet wide until Parlon's Bayou and Jake's Bayou enter the left bank where Bayou La Vigne leaves on the right.

At the ninety-seventh mile the channel enters Lake Chicot, the boatmen's gauge showing 4 feet 10½ inches, February 14, 1874. This lake is a broad mud flat, thickly strewn with snags and whole trees, whose roots and tops appear above the water.

The line of survey followed the steamboat channel from the ninety-eighth mile, being carried on pyramidal stations of cypress poles, driven with a heavy mallet, and braced with boards.

This channel is crooked and shoal, giving barely six feet in the worst place. Three of Mr. Charles Morgan's coal-barges have been sunk here on snags; the last while the party were on the lake. Chicot Pass, from Chicot to Grand Lake, is reached at the one hundred and first mile. It is 500 feet wide, 36 feet deep, one mile long, and has arable banks.

Grand Lake is seven miles wide and twenty-eight miles long from Chicot Pass to Berwick's Bay.

The average depth is greater than that of Chicot, although the deepest soundings across the head, from One Mile Point to Turkey Island and from Chicot Pass to One Mile Point, was only 10 feet. The channel passes between Shaw's Island and Turkey Island, rather nearer the former, and there is less difficulty after passing these islands, the boatmen having staked the channel with poles capped with palmetto. On the right are the passes of Lake Fausse Point; on the left six large bayous return from Grand River, of which the Two Pigeons, Catfish, and Cowan are navigable for lumber-tugs. Channels lead into the deepest part of the lake from each of these bayous.

Opposite the one hundred and fourteenth mile, near Miller's Point, lies the wreck of the Queen of the West. At the one hundred and nineteenth mile Bayou Boutté leaves left bank in a handsome bay, showing 9 feet at low tide. Below this point the left shore is thickly strewn with live-oak trunks and roots, and bears unmistakable evidence of the abrasive effects of storms and the prevailing winds, which were south-southwest during the survey.

There are no houses, nor is there any arable land on the left bank from the one hundred and second mile to the one hundred and nineteenth. At the one hundred and twenty-third mile the channel enters Cypress Island Pass, 1,100 feet wide, 27 feet deep. An abraded island in the middle of this pass, about 800 feet long, has 5 to 10 feet water on it, but makes the pass dangerous on account of the live-oak trunks with which it is covered.

Boatmen are desirous to have a light-house on Cypress Island, and at night their practice is to whistle from the head of the lake for Joseph Miller, the United States live-oak reserve agent on the island, to place a lantern at his boat-landing, to which they steer.

Three miles below the pass is the wreck of the steamer Thompson, sunk upon live-oak snags, in a fog. The general depth increases rapidly below Cypress Island.

In the one hundred and twenty-eighth mile Bayou Boutté returns through the left bank, 2,487 feet wide, 24 feet deep, in a channel 300 feet in width.

Opposite, on the right bank, the "Old Atchafalaya" leaves the lake through a stumpy, snaggy coast, with a channel 500 feet wide, about 100 feet of which is 25 feet deep. The length of this bayou to its junction with the Teche at Zeno's sugar-house is three and one-fourth miles, and it contains no serious obstructions to navigation. The banks are arable, and cultivated in cane. At the one hundred and thirtieth mile, Bayou American and Grand Pass, each navigable for lumber tugs, return from Bayou Boutté and Grand River.

The deep-water channel commences about 1,000 feet from the north or left bank, and is one-half mile wide toward Navy Commissioner's Islands, the entire width of the lake from Bayou American to the islands being 4,280 feet.

Berwick's Bay proper commences at the one hundred and thirty-second mile, being 1,838 feet wide, with a minimum depth of 40 feet at the one hundred and thirty-third mile, narrowing to 1,450 feet at the one hundred and thirty-fourth mile. Just above the mouth of the Atchafalaya it opens to 1,937 feet, the tidal currents being very strong and the whole opening deep. At Brashear City, one hundred and thirty-seven and three-fourths miles, the gap from Chas. Morgau's depot across Berwick's Bay to Berwick City is 1,853 feet, the depth being 74 feet.

The products of the Atchafalaya country are cotton, sugar, molasses, moss, lumber, staves and shingles. The cotton is all grown above the Courtableau and is sent to New Orleans by the two steamers that run to Washington, or the one that makes a ten-day trip to the Teche country.

The lumber and staves are rafted down to Brashear and the Teche, seven small steamers being engaged in this trade.

Flat-boats and broad-horns from Indiana and Ohio bring down hoop-poles, flour, bacon, and provisions, for sale on the Teche, generally taking the route by Grand River, Seventh Tensas, Jake's, and Rigaby's Bayons, making as short a run over Chicot and Grand Lake as possible, and keeping as near to the left bank as the depth will permit, in order to find shelter in the bayous in case of wind. United States contractors for live-oak have a depot at the one hundred and thirty-fourth mile, on Berwick's Bay, where they collect large supplies of this valuable material from points as far above as the Bayou Chêne, and ship by schooner.

IMPROVEMENTS.

The improvement suggested is merely the removal of obstructions from the channel down to the mouth of the Courtableau, (sixty miles,) out of which stream comes two-thirds of the present river trade. The high stage of water during this survey renders it prudent to double in our estimate the number of snags and logs observed and located above the water or touched in sounding, but the removal of 700 snags and trees from the channel at low-water will give the desired relief.

The "raft" at W. C. Gordon's, in the thirty-fourth mile, will probably require more labor than any other point.

The banks of the Courtableau might be leveed for nearly two miles down from the mouth, through the lowest swamp of the Atchafalaya, in order to concentrate the water and cut out the "Devil Bar," which now forces boatmen in low-water to make a portage of 300 yards.

Such levees, of 9 feet crown and 12 feet height, would contain about 200,000 cubic yards.

The condition of the Atchafalaya below Courtableau is so uncertain and the channels so variable and so dependent on the state of the Mississippi that no immediate works are suggested.

A system of substantial levees might effect the same beneficial change below Cow Head Bayou, (thirty-ninth mile,) that it has already done above, but the settlement is too sparse, and the interests involved too small, to warrant the costly experiment.

The channel in Mongoulois, Chicot, and part of Grand Lake, should be marked with spars of cypress of different colors and shapes, which might be placed in low-water and would be of great assistance to raftsmen and navigators from the northwestern States, who cannot procure pilots and are unacquainted with the channel.

The exhibits herewith forwarded are:

- (1.) General map, scale 31680.
- (2.) Tracings of channel, scale 12600.
- (1.) Tracing of Courtableau, scale 30000.
- (1.) Tracing of Dunbar's map of 1839.

All of which is respectfully submitted.

F. P. LEAVENWORTH,
Assistant Engineer.

Capt. C. W. HOWELL,
Corps of Engineers, U. S. A.

The charts to which reference is made are transmitted herewith.

The survey was made during time of high-water in the Mississippi and Red Rivers. It was, therefore, not possible to locate all the obstructions that embarrass low-water navigation in the Atchafalaya.

The statements of several persons engaged in this navigation have therefore been taken regarding low-water obstructions. These all agree that some good may be done by removing a few snags and log-heaps (remains of old rafts) above the Courtableau.

Below the Courtableau the navigable channel is good enough, except through the Lakes Mongoulois, Chicot, and the head of Grand Lake.

The obstructions in these are shoals and sunken timber, a portion of which consists of logs broken loose from rafts. These latter are shifted about from place to place, and new ones added every year from passing rafts, thus making their location uncertain and their removal a task to be repeated after each rafting season.

Neither the importance of the navigation through these lakes nor hope of anything like permanent improvement will warrant more than Mr. Leavenworth has recommended, viz, the location of buoys to mark the channels now used. Even the value of such marking is doubted, both on account of changes in location liable to occur and of the fact that bush-buoys have been frequently placed by steamboat-men at various points and as frequently swept away by passing rafts.

The proposed railroad bridges crossing the heads of the Seven Tensas are likely to prove greater obstructions than any natural ones now existing. The draw, I am informed, is to be located over the Bayou la

Roupe, which is unnavigable during low-water, while the First and Seventh Tensas, which are the low-water channels, are to be closed.

Captain Atkinson, who, in the employment of Mr. Charles Morgan, has made several trips over this route with coal-tows, states that during low-water he experienced greater difficulty at the mouth of Red River than at any point in the Atchafalaya, and thinks that beyond the removal of a few snags and logs, as recommended by Mr. Leavenworth, no improvement will be of benefit until after improvement of the bar at the mouth of Red River. In this I agree with him.

As to the best method to be adopted for improving this bar there is at present great difference of opinion.

I should not refer to it were it not for the fact that this bar governs the Atchafalaya navigation as well as that of Red River. Ultimately some plan of improvement must be attempted. What with changes that have been produced by and are yet in progress, due to the "Shreve" and "Raccourci" cut-offs, it is not possible to say what method of improvement should be adopted.

The Atchafalaya derives much of its importance as a commercial highway from the navigation of the Courtableau. For that reason Mr. Leavenworth examined the worst low-water obstruction in the latter, about two miles from the Atchafalaya, known as "Devil's Bar," and reports a plan for its improvement.

It has been pretty well established by experiment that dredging such bars as this and the one at the mouth of Red River, affords but temporary results. The commerce of the Courtableau will not warrant the expense of continued or even periodical dredging; hence, if improvement of "Devil's Bar" is attempted it must be on the plan suggested by Mr. Leavenworth, or on one similar.

The expense does not now appear warranted.

The removal of snags and logs from the head of the Atchafalaya to the Courtableau is all that I can recommend. Mr. Leavenworth observed 350 at high water, and assumes that double that number will be visible at low water. This estimate is substantiated by persons familiar with the low-water condition of the stream.

I estimate for the removal of these 700 at \$20 each—\$14,000.

The work is located in the collection-district of New Orleans, and the nearest light-house is at the mouth of the Atchafalaya.

It is a difficult matter to get statistics showing near the amounts of cotton, sugar, and molasses brought out of the Atchafalaya each year, or the amount of plantation and other supplies carried in; therefore I only present Mr. Leavenworth's statement of the number of steam-vessels employed in the trade.

R 15.

FORT ST. PHILIP CANAL AND CONSTRUCTION OF JETTIES FOR THE IMPROVEMENT OF THE MOUTHS OF THE MISSISSIPPI.

Letter of the Chief of Engineers.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., February 4, 1874.

SIR: In compliance with the following resolution of the House of Representatives, dated March 14, 1871—

That the Secretary of War be, and he is hereby, requested to cause an examination and survey, with plans and estimate of cost, to be made by an officer of engineers, for

a ship-canal to connect the Mississippi River with the Gulf of Mexico, or the navigable waters thereof, of suitable location and dimensions for military, naval, and commercial purposes, and that he report upon the feasibility of the same to the House of Representatives—

Capt. C. W. Howell, Corps of Engineers, was, with your sanction, assigned to the duty of making the survey referred to. Having completed this duty and submitted his report, it was deemed advisable to obtain the judgment of a Board of Engineers upon the project proposed by him, and accordingly a Board was constituted for the purpose of considering it in connection with other methods for the improvement of the navigable outlet of the Mississippi River.

The reports of the Board of Engineers and the report of Captain Howell are submitted, as follows:

1. Report of Captain Howell, transmitting a project for a canal to connect the Mississippi River below Fort St. Philip with the Gulf of Mexico through Isle au Breton Pass; with appendixes marked A, B, C, and map marked D.
2. Report of Board of Engineers upon Captain Howell's project.
3. Minority report of Colonel Barnard.
4. Report of the Board of Engineers on the subject of the improvement of the passes of the Mississippi, as an alternative to or in connection with the canal.
5. Minority report of Colonel Barnard.
6. Minority report of Major Warren.

By the method now in use for deepening the channel at the mouth of the Mississippi River, a depth of from 18 to 20 feet at low-tide can be maintained, which will admit vessels of 19 to 20 feet draught.

The annual expenditure of securing and maintaining this depth with a width of 250 feet is \$150,000, and taking into account the sum necessary to supply a new steamer every four years to replace the worn-out one of the two in use, the annual expenditure becomes \$200,000.

By doubling the annual expenditure after procuring two more steamers, (at a cost of \$400,000,) probably a channel 400 feet wide, with a depth between 18 and 20 feet, could be maintained.

This appears to be the maximum effect which may be looked for from the system of dredging.

But from the experience gained in the work the officer in charge is of opinion that the width which can be maintained with the present means will be sufficient, provided the War Department can control absolutely the use of the improved channel, a condition essential to the maintenance of the improved channel, whether it be by a canal, by jetties, or by dredging.

Respecting the practicability of constructing a ship-canal from the river near Fort St. Philip to the deep water of Isle au Breton Pass, all the members of the Board agree that there is no doubt as to its entire practicability.

To determine, however, the best line for the location of the canal across the peninsula, and the best point for its entering the river, and also the position and manner of its entering Isle au Breton Pass, requires further survey, borings, and other examinations and measurements, and the preparation of plans based upon their results.

The Board, excepting Colonel Barnard, submits an estimate of the cost of constructing a canal of the dimensions stated within the limits designated, which it believes to be ample.

From this opinion Colonel Barnard dissents.

Respecting the application of the jetty system to the improvement of the channel at the mouth of the river, the Board, Colonel Barnard dissenting, reports adversely both as to the difficulties attending the construction and the cost of the system.

After a careful investigation of the question of applying this method

of improvement to the mouth of the Mississippi River, I am of opinion that it does not present, either in its construction or cost, superior advantages to the canal plan. One of the chief objections to the jetty system is the unavoidable necessity of constantly extending the piers in the open sea, exposed to the full force of storms.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,

Brig. Gen. and Chief of Engineers.

Hon. W. W. BELKNAP,
Secretary of War.

1.—*Report of Capt. C. W. Howell, Corps of Engineers.*

From the general appropriation for surveys, approved March 3, 1871, there was allotted the sum of \$10,000 for the survey of a proposed route for a ship-canal to connect the Mississippi River at a point near and below Fort St. Philip, Louisiana, with the Gulf of Mexico, through Isle au Breton Pass.*

Under orders from the Chief of Engineers United States Army, dated Washington, D. C., April 18, 1871, the conduct of this survey devolved on the undersigned.

The survey was completed several months ago, but report has been unavoidably delayed until this time.

Report is required on the following points:

- 1st. On the commercial and national importance of the projected canal.
- 2d. On the feasibility of the project.
- 3d. On the probable cost of construction.

These are to be considered in the order named; the data for consideration being obtained from the recent survey, and from other sources available, which are named in the list of authorities appended.

IMPORTANCE.

The importance of securing an adequate outlet for the commerce of the Mississippi Valley is too thoroughly appreciated by the representative men of the valley to require in this report more than a general statement.

The valley principally depends for its development on the products of its agricultural population—on its grains, cotton, sugar, and its beef and hog products. For these there is a large European demand, the supply of which adds materially to the wealth and growth of the country.

Active competition from other sources of supply, favored with cheaper labor and transportation, keeps down the market abroad, so that with our present means for transportation from the far interior to the seaboard the value of the product in the home-market is kept at a figure which does not always fairly remunerate the producer for his labor or offer a stimulus to increased production.

The advantages to be derived from works of internal improvement best calculated to insure the producer a better return for his labor are obvious.

Railroad transportation for cheap and bulky freights over long dis-

* This survey was directed by a resolution of the House of Representatives, dated March 14, 1871.

tances is necessarily, and has been found by experience, too expensive to offer the producer hope for advantage to be gained from increase in number of lines and amount of rolling-stock. He has, therefore, recently turned attention to those known and cheaper routes overlooked during the prevalence of the mania for railroad extension. Of these, the routes via the lakes, the St. Lawrence River and Erie Canal, by the patronage bestowed on them when not ice-bound, attest the importance of similar routes projected. The popular feeling in favor of water-routes from the interior to the seaboard is further shown by the interest manifested in urging the extension of the James River and Kanawha Canal, the project for a canal to connect the Tennessee River with the harbor of Savannah, the yearly demand for continued improvement of western rivers and of the bars at the mouth of the Mississippi River, and finally in this project for the St. Philip Ship-Canal.

The means for securing cheap transportation via the Mississippi River and its tributaries to the excellent harbor of New Orleans are promised by the substitution of lines of model barges, carrying large freights on a light draught of water, and towed by comparatively inexpensive steam tow-boats, for the expensive, short-lived steamboats heretofore engaged in traffic on those waters. The improvement of western rivers is yearly diminishing the risks attending their navigation. The advantages offered for transportation from the West to the sea, via this route, have attracted attention, and increasing capital from at home and abroad, and there is now every reason to expect that these great natural highways will become, as they ought to, the commercial routes connecting the Mississippi Valley with the eastern seaboard and with foreign countries.

That this desirable end may be attained it is first necessary to assure, beyond matter of doubt, adequate entrance to the Mississippi, at all seasons of the year, for sea-going vessels of the largest freighting capacity requisite to afford the cheapest freights.

Congress has heretofore, with yearly increasing appreciation of this necessity, and recently with increased liberality, fostered the various plans presented for giving such entrance. The results have been such as to warrant yet more liberal action.

With the success attending the work of dredging the bar at Southwest Pass during the past two years, the commerce seeking the port of New Orleans has grown rapidly.

Lines of steamships before in the trade have built new vessels for it; other old lines have been attracted to it; new lines have their vessels in course of construction; and sailing-vessels, in greater number than before, have engaged in it, all taking fuller cargoes, making quicker trips, with greater profit to owners and reduced expense to shippers. The cotton-trade of the upper cotton-region, for a time partially diverted from this route, is returning, and a grain-trade has been inaugurated, which promises to attain large proportions.

While the great benefit already derived from dredging is acknowledged, there remains, in the minds of commercial men, doubt as to its continuance to meet the growing demand for deeper-draught vessels.

There is yet more serious doubt regarding the continuance of suitable action on the part of Congress in making appropriations seasonably and in amount to prevent interruption of the work.

Distrust in the continued effectiveness of dredging can only be overcome by long-continued success, and simply retards commercial progress. Distrust in the continued good-will of Congress is of more serious import.

The work in progress is dependent for its continuance on an annual appropriation; it is of a character requiring continued work; suspension for a few weeks or months will permit the natural agencies always at work to obliterate all evidences of previous improvement and return the channel across the bars at the river-outlets to their normal and obstructed condition. Such occurrence would be disastrous in the extreme. It would ruin the commerce now promising such good results, ruin the merchants engaged in it, and destroy confidence in plans for its revival at any future time. Yet such occurrence is not improbable, as evidenced by the past record of the work.

Legislative economy enters too largely into the spirit of American politics to permit of men engaged in legitimate business staking their wealth where it will depend on the turn legislation may take.

What is required to inspire confidence in the future of the commerce of the Mississippi River is a permanent outlet, not one of uncertain tenure.

Dredging, from its dependence on legislative action, does not offer such, nor do I believe it capable of offering more than a depth of 20 feet the year round, a depth not considered adequate. It is conceived that this canal project does. The magnitude of the interests involved appears to warrant a trial of the project.

THE PROJECT.

The project for this canal has been agitated for the past forty years. It has had its advocates principally among local engineers and merchants, but has been recommended by higher authorities as a final resort should dredging fail or ultimately prove inadequate to fully meet the growing wants of commerce. Its feasibility has never been made the main subject of discussion or objection, but it has always been discarded on the ground of its supposed cost, estimated greater than the amount of commerce it was designed to aid was presumed to warrant. This objection has now lost the force it once had, and if at all considered, can have no special weight in deciding for or against the construction of the canal.

The question of feasibility is the only one requiring consideration. To settle this, and at the same time gain the information required for making plans and estimates for the canal, has been the object of the recent survey.

PREVIOUS SURVEYS.

A reconnoissance of Breton Island Pass made by British naval officers about 1775, the results of which were made public, (* in chart submitted,) though made for other purposes, affords the earliest known data bearing on the project.

An examination is reported to have been made by Maj. Benj. Buisson, State engineer of the State of Louisiana, about 1832, on the results of which Major Buisson appears to have originated and recommended this project by his reports, giving to it, at that time, considerable prominence. Outside of bare mention in reports and correspondence of later date, I have found nothing to show that Major Buisson made more than a simple examination on which to base his project.

The representations of Major Buisson, supported by the action of the legislature of Louisiana and of the Chamber of Commerce of New Orleans, induced Congress to authorize an investigation of the project.

* Not published until 1823. Enlarged copy of chart submitted, marked D.

This was made early in 1837 by Capt. Wm. H. Chace, Corps of Engineers, U. S. A., who reported favorably.* This report was based on a hurried reconnoissance, and was not considered satisfactory. In consequence, a survey was ordered in 1838, and made under the direction of Capt. Andrew Talcott, Corps of Engineers, U. S. A., the plot of which is submitted. (Chart C.)

The report of Col. J. J. Abert, Chief Topographical Engineers,† based on the results of this survey, caused the abandonment of the project by Congress.

In 1858 Mr. R. Montaignu, civil engineer, revived the project, made an examination, (the character of which I have not been able to ascertain,) and published a voluminous pamphlet (copy submitted, marked H) in support of his views. The death of Montaignu and the outbreak of the rebellion suspended consideration of the project.

In 1869, the Coast Survey extended its work to cover Isle au Bréton Pass, (chart submitted, marked C,) the results of which agree with those obtained by our own survey. The project was finally brought to the attention of Congress during the winter of 1869-'70, by prominent merchants of New Orleans, and the undersigned directed to report on its feasibility. Such report was rendered, based on the results of a personal reconnoissance, and represented the necessity for making a more thorough survey than had yet been made. Such survey was directed, completed, and its plot is submitted, (marked A.)

THE SURVEY.

The field-work was commenced November 8, 1871, and concluded March 13, 1872. The instruments used were of Würdemann's and Gurley's best make. The assistants employed were skilled in the duties assigned them.

Lieut. H. M. Adams, Corps of Engineers, United States Army, was placed in charge of operations in the field, and has made many of the computations for dimensions and cost of construction.

After measurement of a base and completion of the primary triangulation, the party was divided into three.

Assistant F. M. Eppley was put in charge of all hydrographic work, Assistant Thomas Larkin in charge of topography and leveling, Assistant W. Lannegan in charge of boring party.

The results of the survey are displayed on Chart A, or given in the following statement:

Breton Island Pass.—This is the western of the two passes connecting the large body of water known as Breton Island Sound with the Gulf of Mexico. Its minimum width is about 33,000 feet; minimum area of cross-section about 536,000 square feet; maximum depth in throat of pass, 36 feet at mean low-tide; and depth over the bar at the mouth of the pass, 28 feet. The axis of the pass lies nearly southeast and northwest. The Gulf approach is from the southeast, and is flanked on the one side by the Chandeleur Islands, Errol Islands, and Isle au Breton; on the other by the land forming the east bank of the Mississippi River, the two flanks forming with each other nearly a right angle, having the pass at the vertex.

The approach is well covered except from the southeastward, and offers abundant room and good holding-ground for the anchorage of a large fleet. The bottom is soft and sticky in the deeper portions of the

* See Ex. Doc. No. 173, House of Reps., 24th Cong., 2d session.

† See Ex. Doc. No. 2, page 684, vol. 1, 26th Cong., 1st session.

pass and approach, and hardens from the twenty-foot curve toward the shore-lines. The islands are of sand, and the Mississippi shore-line an alluvial, marshy formation, fringed with sand-reefs. At its head the pass expands abruptly into Breton Island Sound and shoals rapidly.

The great depth of the pass is due to the tidal currents through it. Observations were made to determine the velocities of these currents, floats being used for the purpose, but with such unsatisfactory results as to make them valueless.

A computation has been substituted, based on the record of tide-gauge kept at Sable Point, (diagram submitted, marked F,) the minimum area of cross-section of pass, (section submitted, marked F F,) and the superficial area of that portion of Breton Island Sound affected by the tides through the pass, (see appendix marked G.) "It is best to use such calculations only for the purpose of computing the probable effect of alterations."—(Rankine.) It is for this purpose alone the information is required.

By these computations for the time covered by the gauge-record the velocity of the inward or flood-tide current was found to range from zero to 1.06 feet per second; that of the outward or ebb-tide current from zero to 1.175 feet per second. Higher tides than those observed have been known to occur, but they were of longer continuance than any shown on diagram, and it is possible caused no stronger flood-current than is shown, but a stronger ebb-current. No reliable information could be obtained regarding these extraordinary tides from which to determine the rise and fall that would have been indicated by the Sable Island gauge. It is only known that they seldom occur, are caused by southeast hurricanes, which continue for two or three days, and that during their continuance water from the Gulf has been known to flow into the river, over the lower portions* of the river bank, below Fort St. Philip.

The portion of Breton Island Sound daily filled and discharged through Breton Island Pass has a superficial area of water-surface of about three hundred and five square miles. Its northern and western shore-line is covered by numerous small islands and oyster-reefs, and indented with bays and bayous connecting with lakes in the Lake Borgne Peninsula. The depth of water in the sound ranges from 15 feet at the head of the pass to a few inches at the shore-line. The bayous connecting the lakes with the sound have a depth of from 20 to 30 feet. The lakes are shallow. The shores and bottom are of alluvial formation; the islets generally of sand. There are no streams entering into the sound, and no connection with the Mississippi River, even during the season of high water in the latter; the levees, which extend to Fort St. Philip, effectually cutting off such communication above the head of Breton Island Pass.

Outside of the pass, and at the foot of the Fort St. Philip Peninsula, there is a break in the river-bank known as Cubit's Gap, through which the Mississippi River makes its first discharge to the eastward. This discharge is only during the flood-stage of the river, and during this stage much material in suspension is carried through the gap from the river to be deposited in Bird Island Sound, some of which may find its way into Breton Island Sound, as is hereafter explained.

* The difference between the lowest and highest tides observed by this survey was 3.70 feet. (See Fort Point gauge, diagram F.) The greatest difference observed in 1851 and January, 1852, in Bayou St. Philip, was 4.92 feet. See Humphreys & Abbott's *Physics and Hydraulics of Mississippi*. The first-named gauge was the entrance to the bayou, the second at the head. The modifying action of the bayou could not be ascertained, the old bench-mark at Fort St. Philip having been lost.

The next eastward outlet of the river is through the Passes à Loutre and the numerous small bayous branching from them. These outlets are so situated in relation to Breton Island Pass, as will be seen by reference to a map of the Mississippi delta, that, during the prevalence of southerly winds, some of the muddy water discharged through them must be carried by the littoral current, induced by such winds, in the direction of the pass, and not only cause deposit in the bayous of the St. Philip Peninsula, but on rare occasions, by extending into Breton Island Sound, cause slight deposits there, tending, at some time in the very remote future, to materially lessen the capacity of the sound as a tidal reservoir.

The St. Philip Peninsula, through which it is proposed to carry the trunk of the canal, is entirely (with the exception of the Sand Islands skirting its eastern border) of alluvial formation, the character of which is shown by the borings, sections of which are shown on Chart A.

The greater part of the peninsula is covered by shallow bays and lagoons, the only firm land being a narrow strip along the river-bank, and that afforded by the Sand Islands. The formation is entirely similar to that on which the city of New Orleans and the heavy structures of Forts Jackson and St. Philip are built.

The river, for several miles of its length along the reach available for the river end of the canal, is nearly straight, and the water deepens rapidly from the shore-line. The banks are stable, because through this reach the river-current is parallel to them, and has not sufficient velocity to further abrade them, as it does in the bends above.

The range of the river between extreme low and extreme high water was found to be about 6 feet by reference to gauge-record kept at Fort Jackson during the past year. This has been adopted as the extreme lift of the river-lock for the canal, the least being zero.

The facts above stated, together with those referred to as displayed on charts and in appendixes submitted, are all that are required for the discussion of the feasibility of the project for this canal.

DISCUSSION OF FEASIBILITY.

The feasibility of the project depends, first, on finding Breton Island Pass, in its present condition, not subject to material deterioration as regards depth and other dimensions, within such reasonable period of time as may be assumed sufficient to repay, in the benefit commerce may derive from the canal, the cost of its construction. Of this we are to judge, first, from the charts of past surveys, the earliest of which, fortunately, dates back quite one hundred years. Four of the charts are presented, reduced to the same scale for ease of comparison, and will be found marked A, B, C, and D. Though the soundings on these are not referred to the same plane, (being referred to mean low-tide as determined by observations made during the continuance of the surveys which they separately represent,) from the manner in which the plane of reference was obtained in each case there can be but such slight difference that we may ignore it and compare the soundings as if referred to the same plane.

Making the comparison, we find there has been, within the past one hundred years, no noticeable change in the depth of water over the bar at the entrance to the pass, and that the entrance has, if anything, improved by widening. We find the depth in the throat of the pass maintained, and but unimportant changes in the contour of the head of the pass, where it spreads out into Breton Island Sound. From inspection

of the charts, the conclusion must be such as to warrant belief that no greater changes will be observed during the next one hundred years unless new causes for change are introduced.

Let us consider the possibility from new causes.

The dimensions of the pass are determined by the volume and velocity of the tidal currents through it. These are dependent chiefly on the area of the reservoir to be daily supplied and depleted through the pass.

So long as this reservoir (the west end of Breton Island Sound, and the bays, bayous, and lakes connecting with it) retains its present area, there can be no change resulting from natural causes alone in the dimensions of the pass. That this area cannot be materially diminished by silting, is evident from the following:

The ebb-current through the pass being always stronger than the flood-current, is able to return to the Gulf the greater part of what silt may be brought by the flood-current from the eastern outlets of the Mississippi River. These outlets are at a considerable distance from the pass. The present indications are that the nearest is filling, and we know that the others are pushing out farther into the Gulf, increasing their distances from Breton Island Pass. There is no reason to apprehend the formation of new outlets above the present ones. Should there be, at any future time, cause for apprehending breaks in the river-bank that might result in injury to the pass, comparatively inexpensive levees can be built to effectually guard against them.

As before stated, there are no streams emptying into the sound, and the Mississippi River is securely leveed. There can be no silt brought in from that direction, except through a possible crevasse. There can be no silt brought in from the northeastward through Chandeleur Sound, since the tides through Grand Gosier Pass effectually cut it off. Filling of the sound by the gradual growth of oyster-beds and reefs is barely considerable.

Since existing sources of silt are being blocked up or further removed, and since possible new sources can be easily guarded against, I conclude that the area of Breton Island Sound will remain as now for an indefinite time, and the dimensions of Breton Island Pass remain unchanged from natural causes.

The constructions (the jetties) required to carry the *débouché* of the canal to the deep water of the pass will cause changes, the general character of which may be predicted.

The area of cross-section of the pass will be diminished by the construction of the jetties proposed by 70,000 square feet.

The area of Breton Island Sound remaining unchanged, the volume of water going through the pass to fill or deplete the sound daily will be, after the jetties are built, the same as if they were not constructed. This will cause increased velocities of the tidal currents and increased scour of the bottom, and of the Breton Island side of the pass, until such time as the present area of cross-section is restored.

The axis of the pass will be shifted to the eastward and its direction slightly changed. The contour of the head of the pass will be considerably changed, and the west end of Breton Island will probably, considering the character of its formation, be abraded unless protected by works of art.

From the character of the bottom in the deeper portions of the pass, it is probable the pass will regain its normal dimensions entirely at the expense of the Breton Island side. Unless the end of the island is protected with such protection as may be necessary, the pass will deepen.

The extent of the changes which the jetties will effect can only be defi-

nately ascertained after the construction of the latter. Injurious changes may be prevented by the protection of the west end of Breton Island, as may be found necessary in the course of construction.

While the effect of the proposed jetties on the east side of the pass cannot be accurately predicted, their effect on the west side, on Sable Island, may be predicted with certainty. The angles between the shore-line and the jetties will partially fill with sand and other deposits. This has been the experience of engineers with all jetty constructions on our northern lakes, on our Atlantic seaboard, and in Europe; at the mouths of the Oder, the Vistula, and the Danube, and, recently, at the *débouché* of the North Sea Canal and of the Suez Canal. In all these cases this filling is considered objectionable, inasmuch as the tidal currents (shore-currents) perpendicular to the jetties are not strong enough to prevent the ultimate growth of the shore-line incident to this filling from extending around the jetty-heads and obliging an extension of the jetties themselves. In the case under consideration, it is possible to secure a very strong current passing the jetty-heads, sufficient to insure us against apprehension of being called upon at any time to extend our constructions.

As there will be no current through the canal, we must expect silting immediately between the heads of the jetties, due to eddies from the currents through the pass. It is apprehended that shoaling of the entrance to the canal from this cause will not be rapid, but that there will be required, to free the entrance from such deposit as may be made, each year, the services of an ordinary dredge-boat for several days, or perhaps weeks.

In the trunk of the canal there will be no silt admitted, the proposed arrangement of sluices for the lift-lock being such as to keep all river-water required for the lift from passing into the canal below the lock.

Slight deposit is anticipated within the lock, the removal of which, quarterly or semi-annually, will be a very simple operation.

There will be deposit of river-silt in the fore-bay of the lock, due to an eddy from the river-current. The amount of this deposit cannot be calculated, and it will require occasional dredging to maintain the depth of this entrance to the canal.

The river-bank at the point selected for the head of the canal, as before stated, is not subject to change, and the depth of the river-bed may be expected to very gradually increase with the advance of the mouth of the river gulfward.

In conclusion, I can see no reason from the above to question the feasibility of the project, as it has heretofore been questioned, on the assumption of engineers, that Breton Island Pass will deteriorate and the canal itself fill with silt to such an extent as to require continued and expensive dredging to keep it open.

In regard to the foundations for locks, reference is made to the section of borings (Chart A) and to the specimens sent herewith.

Borings numbered 1, 2, and 3 show, at a suitable depth for the foundation of a lift-lock, a stratum of mud-lump clay, having an indicated thickness of over 20 feet, and its further thickness not ascertained. This I consider well calculated to sustain the lock shown by drawings submitted, if a solid timber platform, here recommended, is employed, or even if a pile and grillage foundation should be adopted.

As no plan of founding will be adopted, even should the construction of the canal be decided upon, except under the advisement of a Board of Engineers, it is not essential that I should here give reasons for favoring the platform.

Boring No. 6, in my opinion, shows that a good foundation may be had for the guard-lock on Sable Island.

Excavation for trunk of canal.—This will be the least difficult part of the work to execute. It will be entirely through an alluvial formation, free, so far as has been ascertained, from rocks, stumps, and buried timber. It can all be done by dredge-boats, provided with suitable carriers to transfer the spoil to the banks.

Canals* have been successfully carried through a similar formation by allowing the excavation of a large cross-section with easy slopes, and by giving the embankments a wide base as compared to their heights. The cross-section of this canal and embankments must be determined while excavation is in progress, and be varied to suit the peculiarities of the formation found in the several sections of the work.

For purpose of estimate, a uniform cross-section† has been assumed with sides given, the slope found in the river at the head of the canal. The embankments of the canal at some points may require protection of their outer slopes by facines or wicker-work, or by a growth of willows. Throughout their greater part, sodding with Bermuda grass will be sufficient to prevent washing of the slopes. Washing of the sides of the excavation may be avoided by introducing the towage system of navigation now in use on the river Seine, in France, and Elbe, in Germany, which, I think, will be better and more economical than a railroad and towing-locomotives on the embankment.

The jetties.—The location of these is shown on Chart A. The foundation available is shown to be a good one. Similarly-constructed jetties have been employed at the Sulina, mouth of the Danube, proving efficient, substantial, and economical.

There can be no doubt of the ability of even an engineer of ordinary capacity to construct these jetties in the manner indicated by the drawings, so as to withstand the strongest seas to which they may be exposed. The dimensions adopted for the purpose of estimate may require modification in the course of construction, as they are based on calculations having factors the value of which could not be accurately determined.

PLANS FOR CONSTRUCTIONS.

The general and detailed plans for the various constructions pertaining to the canal, and herewith submitted, were drawn up more for the purpose of estimate than with a view to their ultimate adoption without modification. They have been as carefully considered as the time at my command for such purpose would permit.

While some points of the plan are original, the greater number, it will be observed, have been adopted from existing works; for example, the general plan and details for gates, &c. (Due acknowledgment will be found on the drawings.) In all such cases dimensions have been changed to suit the new conditions imposed.

The drawings are intended to be so complete as to render a detailed description unnecessary.

GENERAL DESCRIPTION.

The lift-lock is 400 feet in length between gates, 80 feet wide at top, and has a depth of 27 feet over the sill at mean low tide in the Gulf. The side walls and bottom are of béton, the walls faced with granite.

* North Sea Canal of Holland.

† Width at bottom, 200 feet; depth, 27 feet; slope, 1 on 2.

These are founded on a solid timber platform, 6 feet in thickness, extending the whole length and breadth of the lock, composed of layers of 12 inch by 12 inch squared timber alternately crossed at right angles and bolted together in the manner adopted for the caissons for piers of the East River suspension bridge, the whole forming a rigid beam calculated to uphold without deflection the weight of the superstructure. This foundation rests upon a stratum of mud-lump clay known to be at least 20 feet in thickness. Seepage is cut off by rows of close piling extended from the lock 60 feet into the bank. The platform is surrounded by a double row of close piling, the heads of the piles being strongly strapped to the platform.

The gates are of iron, circular in plan, and of the kind known as floating gates. Their flotation is calculated, without ballast, for a draught of $28\frac{1}{2}$ feet, and for greater depths water-ballast will be introduced or discharged, as may be made necessary by the fluctuations of the tides. The miter-sills are wrought-iron trusses. The opening and closing of the gates will be effected by chains and hand-winches.

The sluices for filling and emptying the lock are large cast-iron pipes, laid in the side walls just below the level of extreme low-water in the river. Water is received from the fore-bay to fill the lock, distributed by branch-pipes the whole length of the lock-chamber, then sluiced out through the same pipes into open ditches on either side of the canal. By this method the purest water obtainable from the river is sluiced in on the cushion of salt water already in the lock, and its specific gravity being less than that of the latter, it remains long enough on top to be, with the greater portion of its impurities, sluiced outside of the canal.

The sluice-gates are arranged with hydraulic lift, and are lowered by their own weight.

The lock is located 400 feet from the river-bank. The approach to it is between two timber wharves, which, besides forming the sides of the entrance, are extended on either side several hundred feet along the river-bank, for the convenience of vessels waiting to pass the lock or awaiting towage to New Orleans. The lower approach is similarly arranged.

All the piles used in this and in other structures are to be carbolized by the Seeley process.

The guard-lock is entirely similar in design and construction to one end of the lift-lock. It is intended to close the canal on occasions of extraordinary storms, which raise the water in the Gulf higher than that in the river.

The details adopted for the jetties are well enough shown by the drawings.

The construction is one of a substantial, though temporary, character, and must ultimately be superseded by one of béton, based on the foundation this will afford.*

ESTIMATES.

The estimates presented have been based on the cost of material and labor for small works undertaken in the neighborhood of the proposed canal.

The magnitude of this work will apparently justify belief that material may be obtained at less cost than that estimated. It is also evident that the material used for coffer-work may be taken up and used in other parts of the work.

* The reason for the adoption of this character of structure is, that it will be economical and can be constructed sooner than permanent jetties.

These considerations induce me to leave out of my estimate amounts required for engineering, superintendence, and contingencies.

With this explanation the following estimates are submitted:

Estimate.

For excavation of trunk of canal and sea entrance	\$3,966,673 50
For construction of lift-lock	750,900 00
For construction of coffer for same	250,938 82
For construction of jetties	1,949,497 70
For construction of guard-lock	226,885 80
For construction of coffer-work for same	118,068 28
For construction of wharf and excavation at river entrance	107,839 48

SUMMARY.

1. Excavation of trunk	\$3,966,673 50
2. Construction of lift-lock	750,900 00
3. Construction of coffer for same	250,938 82
4. Construction of jetties	1,949,497 70
5. Construction of guard-lock	226,885 80
6. Construction of coffer for same	118,068 28
7. Construction of wharf and river entrance	107,839 48

Grand total	7,370,803 56
-------------------	--------------

SUMMARY OF CONCLUSIONS.

- 1st. The construction of the canal is a matter of great importance.
- 2d. The project is feasible, and its execution presents no great difficulties to be overcome by the engineer.
- 3d. The total estimate of cost approximates \$7,400,000, in round numbers.

TIME REQUIRED FOR COMPLETION.

If suitable appropriations are made the work can be completed within three years of the date of its commencement.

To do this, an appropriation of \$3,000,000 should be made available for the first year, \$3,000,000 for the second year, and the balance for the third year.

Should completion be delayed a longer time than three years from date, a new dredge-boat will be required, at an expense of about \$250,000, to continue the work of dredging at the mouth of the Mississippi River, maintaining its present effectiveness.

The cost of construction will be increased.

Respectfully submitted.

C. W. HOWELL,
Captain of Engineers, U. S. A.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., February —, 1873.

LIST OF SPECIAL AUTHORITIES CONSULTED.

To ascertain importance of the project.

Statistics from the Bureau of Agriculture, made available through newspaper publications.

Commercial statistics from reports of various commercial bodies.

Report of the Chief of Engineers for 1871, pp. 632-3, &c.

Pamphlet compiled by E. Lorraine, chief engineer James River and Kanawha Canal Company, published by the company in 1869.

Reports of Chief of Engineers, United States Army, since 1867.

To ascertain feasibility.

For character of Breton Island Pass, survey of 1871-'72; Coast Survey chart, 1869; Talcott's survey, 1837; reconnaissances 1775-'76, published 1823.

For character of formation of Fort St. Philip Peninsula and of Breton Island, charts above referred to, reports of various engineers, &c.

Sections displayed on chart of survey of 1871 and 1872.

Specimens of borings.

Tides through Breton Island Pass.

Observations made 1871-'72 at Sable Island.

Observations at Fort Point.

Observations in Bird Island Sound.

Observations in Lucas Canal.

Currents through Breton Island Pass:

Velocity computed, and computations submitted in appendix, marked A.

Velocity computed for increase due to construction of jetties. (See Appendix A.)

Rise and fall of the Mississippi River:

Humphreys and Abbot. Gauge-record at Fort St. Philip in 1851.

Gauge kept at Fort Jackson, 1871-'72.

Effects of severe storms; from statements of residents below Fort St. Philip.

Effects of waves and tidal currents on jetties, &c.

Stevenson on Harbors. Foundations on compressible soils.

Memoir of Gen. Richard Delafield, United States Army, published by order of Light-House Board, December 1, 1868, and several of the authorities cited by the author.

Report of Bvt. Maj. Gen. J. G. Barnard, Corps of Engineers, United States Army, on the North Sea Canal of Holland.

London Engineering, 1872-'73, on same.

Personal observations and experience. Excavation through compressible soils.

Personal observations in New Orleans, at the Mexican Gulf Canal, and on the coast of Texas.

Reports regarding excavations for the North Sea Canal of Holland.

Preservation of timber. Report of T. J. Cram, Colonel of Engineers and Brevet Major-General, United States Army, published by Engineer Department, 1871.

Report made to the Board of Public Works, Washington, D. C., 1872.

Construction of timber jetties. Professional Papers Royal Engineers, Vol. XIII, new series, Paper V.

Reports of United States Engineers on improvement of lake-harbors; construction in béton.

Professional Paper 19, Corps of Engineers, United States Army.

Various reports on application to construction of locks and jetties in Germany and England.

Experience at Forts Jackson and St. Philip.

Previous reports and opinions of engineers and others in relation to the project.

Ex. Doc. No. 173, House of Representatives, 24th Congress, 2d session.

Vol. VII, p. 463, Ex. Doc. 26th Cong., 1st session.

Vol. I, p. 684, Ex. Doc. 26th Cong., 1st session.

Reports, &c., printed by Chamber of Commerce of New Orleans in 1837.

Humphreys and Abbot. Physics and Hydraulics of the Mississippi River.

Memoir of Wm. M. Burwell, esq. Copy submitted, marked B.

Project of R. Montagu, chief engineer, 1869. Copy submitted, marked C.

List of maps and charts submitted.

A. Chart of survey, 1871-'72.

B. Coast Survey chart, 1869.

C. Talcott's survey, 1837.

D. Rec. 1775, &c. Pub. 1823.

Plate I. Plan, section, and elevation of lift-lock.

Plate II. Details of lift-lock.

Plate III. Lower approach to lift-lock.

Plate IV. River approach to lift-lock.

Plate V. Details of coffer-work for lift-lock.

Plate VI. General plan of guard-lock and approaches.

Plate VII. General plan of jetties, sections of same, and details of jetty-heads.

F. Diagram of tide-observations.

F F. Sections of Breton Island Pass.

A.—To compute the velocity of tidal currents through Breton Island Pass.

Given:

1. Tide-gauge record at Sable Point for December, 1871, January and February, 1872.
2. Minimum cross-section of the pass.
3. Area of portion of Breton Island Sound affected.

[Computation by First Lieutenant C. E. L. B. Davis, Corps of Engineers, United States Army.]

Notation and formula.

V = velocity of current, in feet, per second.

a = area of reservoir, 305 square miles.

h = rise or fall of each observed tide, in feet.

t = time between high and low-water, each tide.

b = area of cross-section of pass, 536,000 feet.

ah = quantity flowing through in time t .

$\frac{ah}{t}$ = quantity flowing through in unit of time.

$$V = \frac{t}{b} = \frac{ah}{bt} = \frac{a}{b} \times \frac{h}{t}$$

$$\text{Constant factor, } \frac{a}{3600b} = \frac{305 \times 27,878,400}{3600 \times 530,000}$$

Day of the month.	EBB.			FLOOD.		
	Value of t in hours.	Value of h in feet.	Velocity in feet per sec.	Value of t in hours.	Value of h in feet.	Velocity in feet per sec.
11.....	12.0	1.6	0.5876	12.0	1.97	0.7304
12.....	11.5	2.47	.9464	13.0	2.6	.813
13.....	9.0	2.4	1.1751	12.0	2.9	1.0649
14.....	13.0	2.1	.7118	9.0	1.8	.813
15.....	13.0	2.2	.7457	11.5	1.7	.6314
16.....	12.0	1.8	.6609	11.0	1.9	.7611
17.....	9.8	1.6	.7834	10.0	1.4	.6619
18.....	6.5	0.9	.6101	6.0	0.6	.4406
19.....	8.5	0.6	.3110	7.0	0.6	.3777
20.....	2.0	0.3	.6609			
22.....	10.0	1.3	.5728	12.5	1.7	.3903
23.....	10.0	1.6	.7051	10.0	1.2	.3288
24.....	10.0	1.7	.7491	11.5	1.45	.5556
25.....	10.6	1.75	.7712	12.0	2.8	1.0292
26.....	8.0	1.7	.9364	10.5	1.5	.6285
27.....	11.5	2.0	.7664	12.5	2.5	.813
28.....	7.0	1.8	1.1331	11.5	1.5	.5747
29.....	10.0	1.9	.8372	10.7	1.8	.7413
30.....	10.0	1.7	.7491	9.0	1.5	.7344
31.....	9.0	1.4	.6854	11.0	1.1	.4406
Sum.....			15.0987			13.1573
Mean.....			.7549			.6925

JANUARY, 1872.

Day of the month.	EBB.			FLOOD.		
	t	h	V	t	h	V
1.....	10.0	2.2	0.9694	9.5	1.4	0.6394
2.....	2.5	0.8	.4174	9.0	0.6	.2837
3.....	10.5	0.8	.3357	7.5	0.75	.4406
4.....	12.0	0.55	.2019	8.5	0.57	.3853
5.....	8.5	0.57	.2955	9.0	0.9	.4406
6.....	10.0	1.0	.4406	8.7	1.2	.0773
7.....	8.8	2.1	1.0515	14.5	2.33	.7071
8.....	9.4	2.13	.9985	12.0	2.4	.813
9.....	11.3	2.6	1.0139	13.0	2.4	.813
10.....	9.5	2.53	1.2689	10.5	2.42	1.0158
11.....	9.5	2.5	1.1596	11.5	2.4	.9196

JANUARY, 1872—Continued.

Day of the month.	EBB.			FLOOD.		
	z.	h.	V.	z.	h.	V.
12.	9.0	2.12	1.0379	10.7	2.02	.8319
13.	12.0	2.1	.7711	10.0	1.75	.7711
14.	11.0	0.95	.3805	8.8	1.15	.5758
15.	12.5	1.45	.5112	8.0	0.8	.3305
16.	8.0	0.4	.9203	11.0	0.4	.1602
17.	1.0	0.2	.8813	13.0	0.85	.2281
18.	10.0	0.95	.4186	11.0	1.0	.4006
19.	10.7	0.95	.3912	12.0	0.85	.3121
20.	10.0	0.85	.3744	10.0	1.27	.5506
21.	12.0	2.15	.7895	10.5	1.33	.5581
22.	9.5	1.63	.7561	12.0	2.08	.7638
23.	8.5	1.95	1.0109	13.5	2.1	.6854
24.	8.2	1.64	.8813	13.0	2.24	.7593
25.	8.5	1.6	.8295	14.3	2.22	.6841
26.	9.0	2.22	1.0869	14.0	2.0	.6295
27.	10.5	1.7	.7134	10.2	1.4	.5875
28.	9.5	1.83	.8428	10.7	0.95	.3912
29.	10.0	1.24	.5464	10.0	0.72	.3173
30.	12.0	0.8	.2937	12.0	0.5	.1836
31.	1.0	0.1	.4406	15.0	1.3	.3819
Sum			21.2338			17.2373
Mean			0.6849			0.5560

FEBRUARY, 1872.

1.	1.5	0.2	0.5875	6.5	0.4	0.2712
2.	12.0	1.0	.3672	8.0	0.6	.3305
3.	12.0	1.8	.6609	8.5	1.1	.5702
4.	9.0	1.4	.6854	10.0	1.6	.7051
5.	8.5	1.8	.9331	14.3	3.13	.9645
6.	9.8	2.43	1.0926	12.9	1.9	.6490
7.	9.0	1.9	.9303	13.0	2.34	.7932
8.	10.0	2.54	1.1192	15.0	2.2	.6483
9.	8.5	2.2	1.1415	11.0	1.5	.6009
10.	11.0	1.6	.6410	14.0	1.85	.5823
11.	11.0	1.55	.6309	8.5	1.25	.6420
12.	8.3	1.15	.6106	15.0	0.75	.2203
13.	12.0	0.55	.2019	2.0	0.2	.4406
14.	4.5	0.5	.4896	23.0	0.6	.1149
15.	6.0	0.8	.5875	9.0	1.0	.4896
16.	10.5	0.8	.3357	9.0	0.9	.4406
17.	8.5	1.2	.6221	10.5	1.7	.7134
18.	11.7	1.5	.5649	7.0	1.6	1.0072
19.	16.0	1.5	.4131	9.5	1.5	.6957
20.						
21.				11.0	1.33	.5328
22.	9.0	0.83	.4064	8.3	1.0	.5309
23.	9.0	1.5	.7344	13.5	1.9	.6202
24.	7.0	1.4	.8913	6.5	1.0	.6779
25.	10.0	0.8	.3525	6.0	0.4	.2937
26.	14.0	0.6	.1888	3.5	0.4	.5036
27.						
28.						
29.	7.0	0.7	.4406	11.0	0.95	.3805
Sum			15.6090			14.4231
Mean			0.6244			0.5547

Mean of 76 ebbs 0.6834
Mean of 76 floods 5897

Highest velocity ebb-tide, December 13 1.1751
Highest velocity flood-tide, December 13 1.0649
Lowest velocity ebb-tide, February 26 1889
Lowest velocity flood-tide, February 14 1148
Mean of 76 ebbs 0.6834
Mean of highest and lowest ebbs 6819
Mean of 76 floods 0.5897
Mean of highest and lowest floods 5899

Approximate area of cross-section of proposed jetty, 70,000 square feet. 536,000—70,000=466,000 square feet, area of diminished cross-section.

Substituting this value, the formula becomes :

$$V = \frac{305 \times 27878400}{466000 \times 3600} \times \frac{h}{t}$$

Substituting the values of h and t on the dates of highest and lowest velocities, both flood and ebb tides, we have :

Highest velocity, December 13, ebb-tide	1.1751
Same, with diminished cross-section	1.3516
Increase	.1765
Highest velocity, December 13, flood-tide	1.0649
Same, with diminished cross-section	1.2249
Increase	.1600
Lowest velocity, February 26, ebb-tide	0.1888
Same, with diminished cross-section	.2172
Increase	.0284
Lowest velocity, February 14, flood-tide	0.1149
Same, with diminished cross-section	.1322
Increase	.0173
Mean of increase—floods	0.0686
Mean of increase—ebbs	0.1024

B.—Memoir of the Delta Canal, from the Mississippi River, below St. Philip, into the Gulf of Mexico, near Isle au Breton ; compiled from the best sources, by William M. Burwell.

The immense resource of agricultural and other productions in the valley of the Mississippi, above the capacity of the Southern States to consume, has imposed upon the farmers, merchants, and statesmen of the West the indispensable need of a free outlet to all the markets of the world by way of the Mississippi.

The admitted obligation of the Federal Government to construct this outlet devolves upon it the duty of devising the plan, providing the means, and executing the work. We hold the Government to the responsibility, and are not willing to accept the substitution of any individual or corporation.

Various modes of deepening the outlet passes have been proposed and tried. Their advocates insist that the experiments have not been made under favorable circumstances, and some demand a repetition. The leading plans proposed and subjected to more or less experiments are—

Dredging, dredging out, and carrying away the bar across the channel.

Concentration of current by wing-dams, caissons, and by closing all the passes except the channel pass.

Lighterage by pontoons or camels.

Canalization across the land from deep water in the river to deep water in the Gulf.

We will, therefore, state the various attempts made to remove the bar upon each of the theories cited.

I. By dredging.—In 1839, Captain Talcott, under instructions of the War Department, attempted to open the Southwest Pass with the ordinary bucket-drag. No permanent improvement was effected, for during a single night of storm "twice as much mud" was driven by the Gulf waves into the pass as he had taken away. A tow-boat association, under the direction and at the expense of the Federal Government, attempted to open the same pass. They used the rake and harrow, and after working a year they opened a channel of 18 feet in depth for a distance of about 8,000 feet. This remained open a short time, and was prematurely and permanently closed by a single Gulf storm.

In the years 1868-'69-'70 the Government caused to be constructed, at a cost of \$350,000, a steam-propeller dredge, with all the appliances which science could suggest or experience justify. She was commanded by competent and disinterested officers of the Federal Navy. These men performed their duty faithfully. The dredge-boat was repaired and altered without regard to expense, and the experiment of dredging has been conclusively made. It has failed to maintain permanently a much greater depth of water than that which nature has prescribed as the regimen depth on the bar.* Dredging has, therefore, proved a failure. To deepen the bar at the season when there

* See report of officers in charge of the dredging, stating the injury done to their improved channel by the stormy weather, about 1st September, 1871.

is little current-deposit is not very difficult. The whole labors of a season have been, and may be again, destroyed in a night.

II. *By concentration of current.*—The theory of Mr. Long has been stated by him to consist in concentration of current by closing all the passes except those destined for navigation. In 1835 Messrs. Craig & Rightor entered into a contract with the Government to open two channels 1,000 feet by 18, in a straight line via Southwest Pass and Pass à Loutre, respectively. They built a breakwater by driving strong piles faced, 4 feet apart, connected by 4-inch plank. This dike was built 3,000 feet in the Southwest Pass and 550 feet in Pass à Loutre. As this contract was not renewed or continued, we may infer that the Government was convinced that concentrating the current of the Mississippi by plank walls was not feasible. The experiment of deepening the channel by blasting with gunpowder was then tried, we believe, by the same contractors. It was for a time partially successful, but another storm proved that nature can replace mud under 20 feet of water much faster than man can move it away. The aggregate cost of these experiments has been estimated at more than \$2,000,000.

III. *Ligherage.*—The cost and difficulty of this mode of transportation have never justified its adoption.

Canalization.—No experiment beyond the surveys and estimates heretofore referred to has been made to test the success of a canal outlet. There are two projects before the public, proposing to connect the Mississippi with Lake Pontchartrain and Lake Borgne. The latter approaches completion, and will furnish an excellent mode of conducting the inbound and coastwise navigation along the numerous lakes and bayous with which the Gulf coast is connected. As neither of these side-cut canals can carry into the Gulf the maximum depth of water demanded by the great crops of the West, they cannot be accepted, even if successful, as a solution of the great questions of commerce involved.

Even did these canals offer an adequate outlet, they will have been constructed under corporate authority, and subject to a toll on the tonnage which may pass through them. The cities of New Orleans, Saint Louis, Cincinnati, and Louisville, all engaged in relieving the charges in river navigation, will accept nothing less than a free and adequate outlet to the ocean. They require that all obstructions, from the cities of Pittsburgh and St. Paul, respectively, to the Balize, shall be relieved by free canals, constituting a part of the national highway.

HISTORY OF THE FORT ST. PHILIP CANAL.

Some time previous to the year 1832 Mr. Benjamin Buisson, then the State engineer of Louisiana, suggested the idea of avoiding the bars of the Mississippi by a canal from Fort St. Philip to a deep-water point in the Gulf, off the island of Breton. He made a reconnaissance of the intermediate ground, and based his works of construction into the Gulf upon the hydrography furnished by the best existing charts. From these he deemed the plan feasible, and so far impressed his views upon the legislature of Louisiana as to induce, in February, 1832, the adoption of the resolution which follows:

"It appearing from a chart executed by Mr. B. Buisson, of the coast adjacent to and embracing the mouth of the Mississippi, that a canal six and a half miles long, commencing on the left bank of the river, a few miles below Fort St. Philip, and entering the sea about four miles south of Le Breton Island, would afford an easy and safe access to the river to vessels drawing 20 feet; and being strongly impressed with the importance of an improvement thus brought into notice by the ability and public spirit of an individual, and believing that it would be of a great and incalculable advantage to the nation at large: it is therefore

"Resolved by the Senate and House of Representatives of the State of Louisiana in general assembly convened, That our Senators and Representatives in Congress be requested to bring to the notice of the General Government the probable practicability of such a work, and to urge an early estimate and survey of the same by competent officers."

These resolutions were presented to Congress, accompanied by a memorial of the Chamber of Commerce of New Orleans, and so far met approval that a survey was ordered, which was reported from the War Department in 1837. From the document thus communicated we extract the following: "L. Poole, United States Engineer, says he sounded down Pass à Loutre, and along the coast of Breton Island, and also for several miles above and below Cape Point Au Sable. The deepest water found was near Cape Sable." He adds:

"I come now to the project of an artificial cut from the river to the Gulf. I found near Point au Sable, opposite Breton Island, four fathoms (24 feet) water within three-quarters of a mile of the shore, which is a low sand-bank, apparently unchanging, affording an indication that the sand off this coast is not loose and floating, but hard and firm. About half the distance from the shore to deep water the bottom is hard sand, and, excepting a short distance at its outermost extremity, the remaining half is hard mud, forming a hard foundation for heavy walls.

"The distance from the Gulf shore at this point to the river, as ascertained by the imperfect means I had for the purpose, is about seven miles, over a marsh intersected by numerous bayous,* which cover a large portion of the intervening space but are everywhere very shoal, and presents no important obstacles to the projected work.

"An accurate survey of the coast from Pass à l'Ouvre to a point ten or twelve miles above Point au Sable, including the corresponding point of the river, and minute examination of the character of the soil to the depth which it is proposed to give the canal, will be necessary to determine the best possible location, as well as to establish the certainty of the feasibility of the project. *It is my opinion that it offers a fairer prospect of certain results than any other plan that has been spoken of, of opening the Mississippi to ships of the largest class.* A lock at the junction with the river will prevent the deposit of mud in the canal, and the jetties at the sea may be so placed as to form a perfect artificial bastion."

State Engineer George W. Long, esq., is of the opinion that "dredging out either of the passes would be an ineffectual operation to improve them, for if they could once be cleared out they would soon fill up again." He "does not know how you would succeed with your canal; if you could make it with a lock, you would find it a difficult thing to secure a foundation, and without one it would be doubtful whether the banks will stand or not, and on the north side of the Mississippi River there is too much floating sand for a convenient opening of the canal into the Gulf." He thinks that "the navigation of the Mississippi may be improved by obstructing the smaller mouths with heavy booms, well anchored across them, to retain the drift-sand to be conducted into them for the formation of rafts, to break the current and allow the deposit of the sediment to fill up the channels, and thus ultimately to close up all but a single pass."

Mr. Fred. Wilkinson, deputy surveyor-general of Louisiana, "apprehends heavy back-water from any attempt to block up any of the auxiliary mouths of our great rivers." He says:

"The project of a ship-canal near and a little to the eastward of the Pass à l'Ouvre is certainly, from what I have heard from persons acquainted with the subject, a feasible matter; and from the depth of water stated now to exist in the Gulf of Mexico, into which the canal is to open, (34 feet,) is highly recommendable. The only objection that strikes me is the enormous expense of the attempt, from having to pass through the description of country at the mouth of the Mississippi.

"The excavation of the earth consists in throwing out liquid mud, and, from the disagreeableness of the situation, every labor requisite will cost, of course, in proportion. A ship-canal of only a few miles in length can (including the cost of guard-locks, sets of which, built in the most perfect manner, will be required, both on the ocean and the river) be only reckoned by millions. In case of the ship-canal being resolved on, I have no doubt, judging merely from what I have been informed, and not from actual survey, that the neighborhood of Pass à l'Ouvre is, from its being partly land-locked and sheltered from our prevailing winds, a most eligible location for the same. It is difficult to give a decided opinion without narrow personal inspection of the field of observation, but I presume that building guard-boats, a breakwater, and artificial harbor will be requisite in case of the ship-canal being determined on by the Government."

Of this canal improvement Mr. Wilkinson subsequently says that it is, in his opinion, "perfectly practicable," subject only to the objection stated.

Capt. A. H. Bowman, United States Engineers, reports that, in his opinion, "the only practical plan for securing a permanent ship-channel for vessels of the first class to New Orleans is to cut a canal from some point on the Mississippi above its mouth to one of the arms of the Gulf which approaches nearest the river."

The three last opinions are not vouched for on actual survey by the officers themselves. The most authentic document, based upon and embodying all that had been demonstrated upon the subject to the date of 1837, was the report of Capt. W. H. Chase, of the United States Engineers, predicated upon "a partial survey of the mouths of the Mississippi River and of the line indicated by Major Buisson, State engineer of Louisiana, for a ship-canal, all having in view the improvement of the navigation of the said river." †

Captain Chase says: "The obstacles presented to the easy entrance of the Mississippi by vessels drawing 12 feet of water are productive of great injury to the commerce of New Orleans, and require to be promptly removed, or, failing to be done, the construction of a ship-canal on the plan indicated by Major Buisson should be resorted to.

"By reference to Chart No. 1 the line of the proposed canal is exhibited, commencing at a point about two and a half miles below Fort Jackson, and extending seven

* This coincides with the same sounding reported by Gould, a century before, who reports a bottom along that part of the coast of sand and sand with shells.

† Report of survey of Mississippi River, 24th Cong., 2d session, Doc. No. 173, House Rep.; Executive; signed C. Gratiot, Chief Engineer United States, 24th February, 1830.

miles to the shores of the Gulf, and thence by a jetty 1,760 yards to 30 feet water. It is proposed to carry into effect this plan of a ship-canal:

"I. By a construction of a guard-lock at the junction of the canal with the river. The object is to prevent the flowing of the river into the canal.

"II. The excavation of the trunk of the canal 100-feet wide at top, 30 feet wide at bottom, and 30 feet deep. The object of such large dimensions is at once to provide not only for the entrance of the largest ships engaged in commerce, but also for ships of war of the largest class. The advantages offering for both classes are obvious and need no comment.

"III. The construction of the jetties or breakwaters of large dimensions, having for their base 100 feet, with a depth varying from 5 to 30 feet, and 20 feet wide at top, and raised to the level of high-water.

"The practicability of this plan depends solely on the question whether a lock of the dimensions required for the admission of the largest-sized vessels can be constructed on the banks of the Mississippi. I think the question may be easily answered in the affirmative, for we can refer to the practicability of excavating almost to any depth in the mud of the Mississippi delta, as exhibited at the several works constructed by the United States, and by individual enterprise. At Fort Jackson, on the Mississippi River, the foundations were excavated to the depth of 12 feet, and were kept free from water by means of a small engine attached to pumps of considerable power. The operations at Fort Jackson came frequently under my observation, and I am left in no doubt as to the perfect practicability of excavating to the depth of 30 feet, and also of the practicability of establishing a solid foundation, by piling, for the support of the walls of masonry necessary for the construction of a lock.

"Taken for granted, therefore, that a lock can be constructed, we have only to consider the means of excavating the trunk of the canal and the construction of a shore breakwater. The marsh lying between the river and the Gulf, through which the line of the canal is located, is intersected by several bayous, all of shallow depth of water. Commencing at the river, it is proposed to excavate to a depth of 6 feet, affording sufficient water for the dredging-machine, which will thereafter be employed in the excavations, the canal being excavated to a depth of 6 feet through its extent."

ESTIMATED COST OF CANAL.

Lock 200 by 50 by 20, the excavation including pumping 24,000, at \$1.50 ..	\$36,000
1,000 piles 30 feet long, for the foundation of works and floor of lock, drawn close together at the bottom excavation, at \$8	8,000
6,000 yards cubic stone masonry in hydraulic, at \$15	90,000
Cut-stone work for coping, gates, &c.	6,000
Gates and guard-work on river	20,000
Superintendence, contingencies, including funds for the engineer to adopt any other improvement that may suggest itself during the construction, say	140,000
In the trunk of canal the following dimensions will be required: 100 feet at top, 30 at base, 36,960 feet in length, 2,669,333 cubic yards excavated by steam-dredging machinery, will not require the use of pumps, and may be performed for \$1 per cubic yard, including cost of machinery and every expense	2,669,333

FOR JETTIES OR BREAKWATERS.

Each jetty will require the following dimensions: 100 by 20, depth 5 to 30 feet, 5,280 feet in length, equal to 205,333 cubic yards for one jetty; for two 410,666—\$6 per cubic yard	2,363,336
Channel between jetties, extending from mouth of canal on the Gulf shore to the entrance of the jetty, 1,000 feet in width; depth 17½; 5,280 long; 3,420,000 cubic yards excavation by steam-dredges under protection of jetties, at \$1	3,420,000

RECAPITULATION.

For trade and guard-works	\$300,000
Trunk of canal	2,669,333
Jetties of breakwaters	2,333,966
Channel of jetties	3,420,000
Total	8,619,299

This estimate, swelled to \$10,000,000 by the caution of this eminent engineer, was at that date a preposterous sum to be applied to any public improvement. The West did

not possess the power to pass the appropriation, and the South in its hostility to all such appropriations was divided in its support.

Twenty years later Mr. R. Montaignu, a civil engineer, revived the idea. He based his studies upon the data furnished by Buisson and Chase, and adding thereto a personal examination, which continued for more than six months, produced a plan for constructing the canal by private subscription. In a remarkably able and exhaustive essay he demonstrated that the work was practicable; that its cost would not exceed one-third of the Federal estimate, and that, taking the actual commerce of the river-outlet in 1859-'60, the interest account and expense of maintaining the work, deducted from the receipts, would leave a net profit of 25 per cent. per annum upon the investment. This plan was indorsed by the merchants and other capitalists of New Orleans, and received the approval of the chamber of commerce, the insurance companies, and the press. The war and the death of the projector defeated this proposal, but, with the restoration of peace, the project of a national canal, as recommended by the legislature of Louisiana, was brought forward under the auspices of some of the oldest and most eminent merchants. A committee of the chamber of commerce was appointed, which renewed the recommendation of the work, and pressed its adoption upon the Government. In the mean time mechanical skill has greatly reduced the cost of alluvial excavation, and experiment is demonstrating the entire feasibility of the plan proposed. Dredging-machines will do the work at something like one-fourth the cost of manual labor. Within sixty miles, by water, of the site proposed for this Delta canal, another, connecting the river with Lake Borgne, not only demonstrates, experimentally, all questions of construction raised by the earlier commissions, but will in a few months, at the close of its contract, have at its disposal identically the dredging-machinery required for the purpose. A recent letter, addressed to the writer by M. J. Thompson, esq., civil engineer in the service of the State of Louisiana, offers an estimate of the cost of constructing a ship-canal on the ground proposed, of the dimensions of 300 feet on the top, 200 feet at the bottom, and 26 feet in depth. After making a careful calculation of the cubic earth-work, which he estimates at 1,271,111 cubic yards per mile, this engineer places the cost of the work at \$500,000 per mile. For the guard-locks he considers \$500,000 sufficient; and allowing even a million for the piers, would place the whole cost at about \$5,000,000. This estimate might be reduced somewhat, in the opinion of other engineers, who regard the cost of earth-work at less than is estimated. Five millions is, however, a liberal if not an excessive allowance, and yet how insignificant, in view of the obligation to be discharged and the interests to be developed.

In addition to the example of canalizing the Delta for a connection with Lake Borgne, we are furnished with a far higher and more decisive model of national emulation. Modern science and capital have renewed the works of the Pharaohs, and completed a canal from the Mediterranean to the Red Sea. This work opens with a deep-water harbor of 400 acres, protected by piers of artificial stone. It is embanked forty miles through the lakes Menzaleh and Ballah, through the high lands El Guisr, with a cutting of 85 feet; then into Lake Timsah, where an artificial port has been constructed; then through the deep cuttings of 62 feet at Tousseum and Serapeum; then, at a distance of ten miles, entering the Bitter Lakes, and passing a distance of twenty miles through a channel marked by light-houses and buoys; thence through the deep cutting of 56 feet at Chalouf, through sands and a marsh, a distance of twelve miles to Suez, where it ends in another artificial harbor. The length of this canal is one hundred miles; its greatest surface-width is 328 feet; the least bottom width 72 feet; the depth is 22 feet, which is being increased to 26 feet. This work has been constructed through the alluvion of the Nile and the lakes, through volcanic rock, and through the drifting sands of the desert. The power of obstruction of these last may be inferred from the fact, that between Lake Timsah and Port Said, a distance of about fifty miles, it is estimated that 1,300,000 cubic yards of sand will be swept into the canal annually. "This will give employment to one of the largest dredges for three or four months, working twelve hours each day." In the year 1869, 1,362 ships, of 672,000 tons, entered the canal, and this tonnage has been rapidly increasing.

Here, then, we have a work far more extensive than the proposed canal of the Delta. It passes through similar and also through more formidable formations. It is embanked through lakes, and opens into capacious artificial harbors, formed with artificial stone. It is subject to an obstacle analogous to the sediment of the Mississippi—the drifting sands of the desert.

We will now exhibit the items of—

COST OF THE SUEZ CANAL.

Preliminary surveys from 1854 to 1857.....	\$15, 825, 535
Administration and negotiations	3, 394, 245
Sanitary service for 1866 to 1869.....	121, 410
Telegraphic service.....	34, 000
Transportation, boats, buildings, &c.....	1, 644, 435

To contractors, for materials	\$2, 442, 785
Dredging-machines	6, 819, 240
Workshops	844, 150
Works of construction, canal, &c.	43, 534, 330
Miscellaneous	1, 392, 493
Various branches of management	3, 843, 050
Balance to deepen canal to 26 feet	9, 437, 560
Total	90, 331, 223

This gives us an average of \$806,936 per mile as the cost of this canal, with its two ports, estimated at more than half the amount expended for excavation. In conceding this calculation to be correct, we feel authorized to strike out certain items as inapplicable to the Fort St. Philip Canal. The general expense of administration of the Suez Canal, and the diplomatic negotiations, are excessive and unnecessary. There are other items which would not cost the United States as much as the corporation of Suez; the expense of preliminary surveys and superintendence would be much less. The delivery of supplies on the banks of the Mississippi and the Gulf coast would be cheaper than upon the shores of the Mediterranean. A pioneer ditch, as on the Mobile and Texas Railroad, would deliver the materials of construction along the whole line of canal without the necessity of employing draught-animals for that purpose. The completion of the levee-reparations and the approaching completion of the Lake Borgne Canal will place at the call of the Government a large amount of labor, skilled in, and inured to, alluvial excavation, with a number of improved dredging-machines, now employed in performing exactly the kind of work required on the ship-canal.

ARGUMENT.

The capacity of the soundings off the shore of the Gulf of Mexico, and through that channel to the sea, is shown to be ample for the passage of any commerce. These soundings are unchanging. A century ago the British government ascertained and published a chart, which has been verified by subsequent surveys of the United States, and found to be the same. Congress has ordered a survey and reconnoissance of the work, with estimates of probable cost. They will be made during the ensuing fall and winter by the intelligent officer at present in charge of the Essayons, Capt. C. W. Howell, United States Engineers. This, then, offers an ample and permanent passage and anchorage at the canal-outlet. The depth of the river is sufficient at the inlet for all possible purposes. An adequate and undoubted depth of water for the inlet and outlet between the river and the sea is then established—not on conjecture, but upon fact. The first term of a deep-water outlet established, it becomes a proposition of expenditure and science to effect it.

THE FINANCIAL QUESTION.

It is not our purpose to review the mechanical, financial, or scientific estimates of the engineer. The duty of the Government and the public necessity for a great work having been established, the details of execution rest with the proper authorities.

With the immense domain and incalculable values locked up within this Mississippi Valley, it would seem a matter of small moment what portions of those values shall be devoted to their development. It may be added, moreover, that when the Government has already expended several millions for the canal around the Des Moines Rapids, and nearly as much more in making the canal around the falls of the Ohio, it would be poor economy to refuse the canal from the Mississippi to the Gulf. This will complete the system of artificial relief to the whole navigable length of the Mississippi and Ohio Rivers. Without the Delta Canal to give outlet to the developed products of the West, the enlarged capacity of the upper rivers must fail of its full effect.

But the Government, in acknowledging the obligations to keep open these outlets, will naturally seek the least expensive and most certain way of doing so. That mode which insures a vast commerce against obstructions is the most economical. Cost what it may, the Government cannot afford to dispense with it. The annual cost of keeping open the passes by dredging, with the cost of repairing and replacing the vessels employed, may be safely set down at \$250,000. If we assume the cost of the Fort St. Philip Canal, as stated in this paper, say five millions, the Federal Government need only omit that amount of bonds bearing 5 per cent. interest, and the amount of interest would be but little more than the present cost. The complete execution of the whole work would save much trouble in organizing an annual expedition against the obstructions, when valuable lives are risked in unequal combat with the elements and the epidemics. The dredge-boat Essayons has been obliged to interrupt her work during the summer of 1870 from this last cause.

There is, however, another reason why those who are especially interested in the

outlet navigation should desire this permanent improvement. With the most sincere desire for the preservation of peace, foreign and domestic, with the utmost faith in the disposition of the American people to keep every obligation, we cannot expect to be always exempt from political disturbances which have affected all nations at all times. If the annual appropriation for dredging the outlet should fail or be suspended from any of those legislative accidents so familiar to all, nature nevertheless brings her alluvial tribute and lays it upon the threshold of the ocean, and the people and products of the West are barred of their passage to the world-markets. Commerce is suffocated. Who can compute the loss, the discontent, or the disappointment? If, however, the Government shall apply a capital amount of bonds, the interest on which will be not much more than the present outlay, to open the Delta Ship-Canal in free outlet to the ocean, no accident or misfortune, no political mishap nor party defeat can deprive the Great West of a permanent, perpetual, and perfect way of communication with the world. It has been remarked by a sagacious American, of the canal across Suez, "But whether the canal company be a success or a failure to those who have thus far invested their money in it, is of little moment in the world's history. The new route is there; it will remain, and if one set of persons cannot make it pay, then it will fall into the hands of others." This has been already verified.

The Fort St. Philip Ship-Canal would thus effect an ultimate economy in the annual expenditure of the Government; for it would encourage greatly the importation of dutiable goods in exchange for the developed products of a country otherwise inaccessible to agricultural industry. The West will have a permanent and adequate outlet to the sea, and will receive a large part of the national expenditure, and of its own contributions for that purpose. It must not be forgotten that as the American empire spreads along the slopes of the Rocky Mountains it must pass a point at which the exportation by rail of the cereal crops grown on the parallel of our chief Atlantic cities must become unprofitable. This will be obvious from a single example: The average quantity of wheat grown on an acre in Massachusetts is 18 bushels, worth \$1.75 per bushel. The aggregate cash value of an acre grown in wheat is \$31.56. The average quantity of wheat grown upon an acre in Minnesota is 16.3 bushels, and the average cash value of an acre of wheat is \$9.61. This would make a bushel of wheat grown in Minnesota worth to the farmer less than sixty cents. When we deduct from this price the cost per bushel of moving the wheat from the Minnesota farm to the depot, there can be little inducement to its culture, nor can it be carried much farther back, unless some cheaper mode of transportation be provided. We have taken these statistics of production and value from the Annual Report, 1869-70, of the Agricultural Bureau. The same report supplies an appropriate comment in saying, "The continuous planting of new lands of the West with wheat is running west, year by year, the culture of wheat production and increasing the distance of transportation, while the railroads, by their combination and advance of tolls to secure dividends upon watered stock, are increasing in equal ratio the cost of freights." The quantity of edible grains from west of the Mississippi—including, also, the product of Wisconsin—is about two hundred and fifty millions of bushels. Now, the extent to which the freights upon this product can be reduced, the inducement to emigrants to go upon the immense area of unoccupied Territories of the republic, will be increased. The experience, however, of all ports from which grain is exported shows that vessels of very large burden, of great draught, and of peculiar build, are required to conduct this trade with economy. The largest class of vessels trading from Chicago over the St. Clair Flats are of about 2,500 tons, and of 12 feet draught. The Welland Canal only allows the passage to sea of ships of about 600 tons, drawing 12 feet. These figures allow the exportation of cargoes of about forty thousand bushels of grain through the lake-outlets. As the increase of draught and tonnage in the vessel diminishes the cost of transportation per bushel, it leaves to the farmer so much more of the price of his wheat in the ultimate market.

WARNING TO THE WEST.

The immense additions to the wealth and numbers of the Upper Northwest, the opening of the St. Lawrence River and the Canadian canals in free passage to American commerce, and the rapid development of trade and immigration by that route, point to the rapid organization of a new sectional interest, to be based upon lines of railroad crossing the continent to British Columbia and Puget's Sound, by way of the Red River of the North. The Hon. W. Kelly, in a recent address on the "New Northwest," describes the country intervening between Lake Superior and the Pacific to be fertile and of a mild climate. He expresses confidently the opinion that there will be a column of States carried across the continent, but predicts that the largest city on the Pacific coast will be at Puget Sound, because of its abundant food, fuel, and its moderate temperature. The tendencies are toward an admission of the Canadas, with a population of four and a half millions, into the Union. With the present political power along the frontier States of the Northwest interested in the Canadian and other

routes to Europe, and with the fact that the exports were 23,000,000 bushels of wheat last year by the St. Lawrence, an increase of seventy per cent. within three years past, the *present* West should see the power and the motive to erect the St. Lawrence route into a rival of the Mississippi. What means so simple to enhance the advantages of the eastern routes as by employing the vote or the veto to suspend the annuity for dredging the mouth of the Mississippi? Regard the trade and travel between the West and the tropical countries. See Baltimore, New York, and Boston competing to supply western products in exchange for coffee, sugar, and other commodities. Is there not reason why the West and Southwest should apprehend indifference, if not opposition, to the direct outlet of the valley? And let it never be forgotten that, with even the cessation of a single season, all the work must be repeated.* The West will not have the power to protect itself forever. Under the present census, let its merchants, manufacturers, farmers, and statesmen demand that this natural and indispensable outlet shall be placed on such a footing as that no future inaction or opposition can impair its usefulness.

Why, then, should not St. Louis, Cincinnati, Louisville, and the whole country that they represent, demand at once the permanent opening of the Mississippi outlet by a canal which can never be closed, suspended, or taken away?

It will be said that the present mode of improvement by dredging is successful. We take pleasure in stating that the latest report of the officer in charge of that work shows a good broad channel worked out by the dredge to the depth of eighteen feet.† Vessels can now be safely consigned to New Orleans without fear of being stranded on mud-lumps. To the dredge-boat now at work on the pass and bars will be added, in January next, a consort. This will insure adequate navigation. We hail this as a temporary measure; it will keep the commerce until a more permanent work shall have been executed. It is, in fact, a scaffolding for the erection of the Fort St. Philip Canal. We have given the reasons why that work should be preferred to any substitute.

The navigation of the Mississippi cannot be materially enlarged without providing for the reduction of freights.

This cannot be effectually done without enlarging the capacity of the vessels carrying grain to a trans-atlantic market, and this involves the necessity of opening an outlet-channel adequate to carry the large cargoes essential to cheap freights. The Des Moines Rapids Canal and the Fort St. Philip Canal are, therefore, works necessary to the development of the public domain west of the Mississippi. They are as much auxiliary agents of further sale and settlement as the railroads based upon public subsidies which traverse it. We will, however, take even a more enlarged view of the necessity for this—

OUTLET OF AN EMPIRE.

The surface drained by the Mississippi exceeds 750,000 square miles, without regarding the fact that the column of States on the eastern slope, in the gorges of the Rocky Mountains, will be compelled to draw their tropical commerce through the Mississippi outlet. The population of this area numbers little less than 17,000,000, upon an average of about 20 to the square mile of the settled portion, a density capable of almost indefinite expansion. To the normal rate of natural increase may be added a large accession of foreign immigrants. This region exhibited in 1869 the following statement—

OF FOOD PRODUCTION.

	Bushels.
Indian corn	650,000,000
Wheat.....	180,000,000
Rye	4,000,000
Oats	170,000,000
Barley	14,000,000
Buckwheat	5,000,000
Potatoes	40,000,000
Total.....	1,063,000,000

OF ANIMAL FOOD.

There was received in 1869, at—

	Beef-cattle.
Chicago	403,502
St. Louis	222,000

* The normal depth of the river will always return. Daniel Cox, in a work upon the English and French colonies, published in 1727, says: "The Mississippi River has seven mouths, with a depth of fourteen feet on the bar."

† Channel changed by stormy weather, September, 1871.

	Beef-cattle.
Cincinnati, (estimated).....	150,000
Louisville, (estimated).....	75,000
New Orleans, (estimated).....	100,000
New York from Western States	186,000

Total	1,136,502
Hogs packed in the western cities, 1869-70, (estimated).....	4,000,000

This immense product, it must be remembered, is the surplus of live stock held in the country. These are computations of the leading articles of production. They omit wholly the manufactures, whose value may be inferred from the annual productions of the four chief cities of the valley—

St. Louis.....	\$150,000,000
Cincinnati.....	125,000,000
Chicago, (estimated).....	100,000,000
Louisville, (estimated).....	75,000,000

Total.....	450,000,000
------------	-------------

The immense provision-product will be combined with the coal, iron, lead, copper, salt, lumber, cotton, and innumerable other commodities which are or may be developed, so that if the export of provisions shall decline, their value will be more than made good in the exportable commodities into which they will have been transformed. Confining ourselves, however, to ascertained products which require an improved outlet to the ocean, we offer the estimate which follows:

TOTAL TONS EXPORTED AND EXPORTABLE FROM THE MISSISSIPPI VALLEY.

	Tons.
Cotton.....	350,000
Tobacco	36,000
Grain.....	2,000,000
Other provisions.....	120,000

Total.....	2,606,000
------------	-----------

Here, then, is a probable commerce that far exceeds that of the Isthmus of Suez at present. Will our Government hesitate to give five millions when individuals have subscribed a hundred millions for a similar work in a foreign land?

These figures omit much detail of authentic statistics. They may appear startling, but they are true. When we reflect that this vast area has only been subject to the control of intelligent man for about three-fourths of a century, and note its prodigious increase of wealth, population, and progress, no estimate can be excessive. When Mr. Burke, in his great and unavailing effort to preserve the British Union, would have impressed upon the nation the vast growth of the American colonies, he supposed it would appear to many incredible. He therefore said that the growth of the colonies was so rapid that even if the estimate should be in advance of reality, "while we pause to make the figures, the fact is upon us;" a pardonable hyperbole equally applicable to colonies of those colonies. Our statistics grow stale even while we expose them to inspection.

We ask every American legislator, is not such an empire, with such inhabitants and such resources, capacities, and destiny, entitled to a commercial connection with the outer world? Is not the standard of civilization in literature and the arts in St. Louis, Chicago, Cincinnati, New Orleans, sufficiently high to justify these people in demanding facilities of commerce equal with any other portion of the republic? Shall a people who pay two hundred millions of annual taxes toward the support of the common Government be denied a highway to the sea at a cost of the annual interest on their contributions? They have ceded to the National Government the right of taxation upon imports, the natural fund for removing physical obstructions to commerce. They have yielded the paramount jurisdiction over their natural highway to the ocean. This great highway and outlet was given them by the law of nature and of nations. It has been guaranteed against hostile obstructions by the valor of the people who inhabit its shores. Shall this great highway, which neither foreign nor civil war could obstruct, be shut up by an accumulation of mud? Shall these vast values be incarcerated from market for the pittance necessary to relieve and deliver them? For such services and for such contributions, for such undeniable right and obvious policy, is any appropriation excessive or unreasonable?

DISTRIBUTION OF THE EXPENDITURE.

In the application of the money asked for the construction of the Delta Canal every dollar may be paid to some important domestic interest. The workshops and ship-

yards of the North and West will supply the engines, dredge-boats, implements, with the food, coal, and animals. The Southern States will furnish much manual labor. New York and New Orleans will conduct the financial administration. As every part of the Union will pay its quota of the cost, every part will participate in the distribution of the expenditures. Not only will the construction of the work promote the interest of all, but it will add to the strength of the republic by removing a cause of sectional discontent. This consideration comprehends a value not to be computed in money; it has sometimes cost millions in its consequences.

The Federal Government should not limit its aid to the specific work under consideration. It should adopt a policy by which all impediments to the navigation of the main stream of the Mississippi will be removed. It is a natural highway, governed by national authority in its whole navigable length. This duty of the Government may be most effectually performed by canalizing the main branches at the Des Moines Rapids, the Falls of the Ohio, and the Muscle Shoals of the Tennessee. The ship-canal at Fort St. Philip will complete the system.

The West should moreover impress upon the President his promise to revive the trade treaties with Spanish America, and insist on the same liberal reciprocity in regard to their commerce with the Mississippi Valley as has been granted by England in regard to the Canadas. If the great West is at this moment guaranteeing and guarding the sovereignty of Spain over Cuba, and the integrity of Mexico, Colombia, Venezuela, Chili, and Peru against European aggression, there should be some compensation in the facilities of trade with the United States. The same may be said in regard to an equalization of the postal subventions connecting the Mississippi Valley with all the principal foreign ports to the south of New Orleans on this continent. These vital issues should be embodied in the platform of every western political convention; they should be insisted on by all candidates of all parties for the Presidency or for Congress.

We bring this extended memoir to a close by enumerating the measures proper for adoption by Congress in compliance with a national duty:

1. To require an immediate report from the proper department of the Government upon the practicability and probable cost of the Fort St. Philip Canal.
2. To direct the construction of such canal, if deemed expedient, by contract with responsible contractors.
3. To appropriate an amount of Federal bonds which will net, in market, the sum necessary to construct the canal and ports.
4. To include in the appropriation for the annual operations for improving the mouths of the Mississippi River a sum sufficient to meet the annual interest on the capital cost of the canal as well as for superintending and keeping the same in repair.

C.—Project of a ship-canal between the Mississippi River and the Gulf of Mexico, by R. Montagu, Civil Engineer.

INTRODUCTION.

Of all the elements which enter into and affect the value of commercial products, none has made more progress toward amelioration, during our time, than the question of mode and means of transportation. This truth needs no further proof when we remember that we have seen the inauguration of railroads and steam navigation. This extraordinary development in the means of communication was commanded by the first of all social necessities, that of relations and exchange. The prosperity of a country is in proportion with the extent of its sphere of expansion. The creation of a great commercial road, by land or by sea, causes rich and populous cities to rise from the soil, and former queens of commerce see life and motion leave them and take another direction, if some new road is inaugurated which overthrows the long-established habits of trade, and diverts them from their ports.

No question, then, can present greater importance for the prosperity, and even the existence, of a great commercial mart. It must tend to increase constantly the extent of its circulation by the creation of new means. It follows, therefore, naturally that its first duty must be to keep in order and improve those means which it already possesses. Such is at present the position of New Orleans.

Commanding the greatest of rivers, she sees the productions of the vastest agricultural valley that exists brought daily at her feet. These unique advantages, which she owes to nature alone, insure her a prosperity unrivaled and boundless from the day she will choose to develop them by her industry and her activity.

But to this, nature has attached a condition. In establishing New Orleans as the queen and mistress of the Lower Mississippi, it has imposed on her the duty of making the access thereto easy, sure, and constant. She owes the fulfillment of this condition to the whole commercial world, for, from the day that transportation through the

mouths of the Mississippi River would become too burdensome and onerous, freights would have to take another and less direct route, and the commerce of the Old and New Worlds would receive a fatal blow.

But the first consequence of this perturbation would be the complete ruin of New Orleans and the division of her profits among certain other commercial centers, possessing perhaps less natural advantages, but gifted with more wisdom and enterprising activity.

Yet it is to this result we are marching rapidly, and we cannot even plead that we have not been warned in time. Science, men of experience, seamen, and merchants, the facts themselves, have fully demonstrated, beyond the shadow of a doubt, that the Mississippi offers no longer to our vessels an immediate, easy, and safe access; that between the mighty river and the sea a wall has arisen, increasing every year; that while it would be indispensable, in order to reduce the costs of transportation, to introduce in our great cotton-mart the use of ships of the largest tonnage, it has become necessary to construct, specially for the New Orleans trade, vessels of middling capacity, in order that they can surely cross the bars that obstruct the entrances to the river.

In presence of such facts, and in presence of the formidable competition which the North and East are making to draw to their markets the productions of the Upper Mississippi, we can foresee plainly the day, not far distant, when our great port will only be occupied by the coasting-trade and opened to the navigation of smaller craft; when commerce will have taken another route; when our merchants and shippers will see the productions of foreign countries reaching them only through northern or eastern channels. Then New Orleans will have passed from among the great commercial cities of the world.

Are these dangers so imminent? This is what our deplorable indolence has, to this day, refused to convince us. It is in vain that official reports, the complaints of ship-masters, the losses suffered by shippers, the dissatisfaction of consignees, the losses paid by underwriters, have clamored to our ears like so many alarm-bells. We are loath to suppose that the prosperity we have so long enjoyed can cease, and as long as ships arrive at our wharves, at whatever cost or condition, we remain slumbering in treacherous security.

There is, besides, an excuse to be found in the difficulties of the question itself. The most judicious minds, who agree that something must be done, cannot come to any conclusion. Scientific men do not agree as to the origin of the evil. Practical men do not agree better as to the proper remedy to be applied. There is only one point on which all unite, that it would be necessary to undertake a struggle against nature itself, the result of which must be doubtful, expensive, and of short duration. However, it will be admitted that this is no reason why no action should be taken, and that if the question cannot be solved directly by open and bold measures, there may still be some other means to arrive at a solution. This we come to proclaim openly.

Yes, the danger is so imminent that not one instant should be lost, not to repair the harm already done—that is beyond the power of man—but to free ourselves from its future consequences. Yes, something can be done; something simple, logical, decisive. Thus to prove indisputably that the powerful hand of nature closes the mouths of the river to commerce, and that, far from having the power, by any effort of science, to conquer this obstacle, we tend to increase it every day by necessities of another order, such as the consolidation and raising up of our levees, will be the first part of the task we have undertaken.

To substitute to this opening which escapes us, another, wide, easy, practicable at all times, free from all the inconveniences of the present passes, and free from all danger of closing itself subsequently, will be the second part of our task.

The double demonstration, if we prove adequate to the important task we have had the honor to be intrusted with, contains the salvation and future of New Orleans.

PRESENT AND FUTURE CONDITION OF THE PASSES.

It would be extremely difficult to make a retrospective study of the former condition of the Mississippi, and the importance of the deposits that obstructed its bed during the early times of the colonization, or even until our time. Official information on this subject is completely wanting. The able State engineer, Mr. Louis Hebert, said in his report of 1859:

"We are still quarreling among ourselves to decide, by words and by arguments founded on conjectures, what the Mississippi was, what it is, and what it will be. Our knowledge of the past rests on facts, gathered here and there, partially in one year and partially in another; now by this person, then by another—incoherent facts, disjointed by time, localities, and circumstances."

In presence of such declaration, the scarcity of anterior documents and the contradictions they contain, are no more surprising than the antagonism of opinions on

actual facts, for in such matters certainty can only be based upon a long series of connected and systematical observations.

Thus, on one side, one of our most distinguished hydrographers, Dr. Cartwright, states positively that the bars at the mouth of the Mississippi have not increased, as it is generally believed, but have remained the same since one hundred and forty years, excepting changes in the direction of the passes and differences of one or two feet in their depth, the effects of winds and tides. On the other hand, we find data in old works on this subject stating that, in 1722, there was 25 feet of water on the bars, and that this depth was reduced to 20 feet in 1767. In our days the depth is only 15½ feet, as shown by the last soundings made by Engineer Hebert, and more recently by myself.

It is certainly much to be regretted that a greater number of observations cannot be gathered, which would enable us to determine and discuss the law that governs this gradually increasing obstruction, but it is, nevertheless, safe to affirm that the established natural tendency is a progressive diminution of the depth of water on the bars.

Another fact resulting from an examination of the past is the continual lengthening of the delta of the Mississippi in the Gulf. Comparing the exact soundings made by Captain Talcott, United States engineer, in 1838, with those made by the same gentleman in 1851 and in 1852, we find the deposits of alluvion advanced seaward at the mean rate of one mile in every 15 years, which represents a progress of 350 feet annually.

Passing from the data found in the past to an examination of the present, we draw from official sources the following description of the Mississippi and its mouths in their actual condition:

After running a distance of five thousand miles from the Rocky Mountains, with a mean inclination of seven inches per mile; after crossing a basin two thousand five hundred miles in width, and presenting a surface of one million one hundred and twenty-three thousand one hundred square miles, the Mississippi flows in a single and majestic channel to within ten miles north of the twenty-eighth parallel, where the river divides itself in three branches: One, following the axis of its first direction, meanders until it empties into the Gulf of Mexico. It is the South Pass. Another inclines 35° westward. It is the Southwest Pass. The third branch is no less than the principal channel, which, relieved by these two large outlets, changes completely its direction. Coming from the northwest, it inclines eastward from the English Turn, making an angle of 125°, and continues in this new direction until another subdivision takes place, a portion of the mass of water flowing southward, forming at the Balize the Southeast Pass, the remainder continuing eastward, inclining somewhat toward the north, and forming the Pass à Loutre, or Northeast Pass.

Thus, in reality, the river has four outlets to the sea, but only two interest commercial navigation. The South and Southeast Passes are already too much obstructed to be hereafter counted as regular outlets.

We will therefore confine ourselves to describing the Southwest Pass and Pass à Loutre.

Here is what Mr. Hebert, the State engineer, says about the latter:

"The bar at Pass à Loutre has only a width of 250 yards, and the channel across the bar is 200 feet wide. A mass of mud in the center divides this channel in two. The most narrow has only a depth of 12 feet; the other is wide enough to give passage to a ship and two tow-boats, and has a depth of 15½ feet. The channel is nearly straight, and, with the exception of the elevation in the center and of three others on the side, is free from obstructions. The bottom seems to be of the same nature as that of the other pass, sometimes hard and sometimes soft. The direction of the channel is such that ships can sail on the Mississippi from English Turn, with prevailing winds, during eight or nine months of the year. This would relieve them of the expense of towage."

As to the Southwest Pass, it had, in March, 1858, 15½ feet of water in the channel at mean tide. The bar is one mile wide, and the channel quite narrow and crooked. Mr. Hebert calls "the channel" that which has the greatest depths; for the bar is cut in all directions by holes and small channels.

Such are, at this day, the two principal outlets of the greatest line of interior navigation in the world. We could prove this description to be faithful by multiplying quotations; but we deem it sufficient to warrant the conclusion that the Mississippi has, properly speaking, no reliable open outlet to the sea. Theory, as well as the experience derived from the many attempts made or projected, will demonstrate that the Mississippi can never, at any cost, have such an outlet or mouth.

There are two opposite systems to explain the formation of the bars, and each of these systems is erroneous by its exclusiveness; for both are true to a certain extent.

One of these systems attributes the accumulation to the deposit of the immense masses of matter carried along by the turbid current of the river, which is necessarily precipitated when the force of the current is destroyed by its junction with the sea. This is the old theory of fresh-water alluvium.

The other system denies that the river has anything to do with this accumulation,

and explains it as altogether caused by the action of the sea. This is the modern theory of bottom waves. The sea continually tears up its shores, and, under the impulse of winds and currents, the fragments washed away by the waves are carried to enormous distances. When the waves strike against an obstacle, the speed decreasing and even disappearing entirely, the sea abandons all the solid parts it carried, and these, sinking to the bottom, form shoals and accretions. When the obstacle happens to be a stream, this deposit forms a bar at its mouth.

In the excellent work of Linant Bey and of Mougél Bey, on the Isthmus of Suez, we find that operation described as follows:

"The carrying power of the sea depends upon the size of the tides and the direction of the winds, as also of their intensity, combined with that of the currents which are found in all the seas. Thus while considerable masses of the matter are set in motion along the sea-coasts, the rivers, and particularly those of a great length, only carry to the sea muddy matter of so little weight that it is carried afar and deposited in the depths of the sea. We have a remarkable instance in the river Nile, whose waters, at the period of inundation, can be distinguished, from their peculiar color, at a distance of more than ten leagues at sea. All the accretions and shoals up to eighteen miles of its mouth are muddy, while all the bars at its mouth are composed of sand."

The obstacles at the mouth of the Nile, therefore, proceed evidently from the sea. To demonstrate this with still more certainty, we will quote the reasoning of the engineer, Bonniceau, in regard to the alluvion in the river Mersey, in his excellent work on the navigation of tide rivers:

"If the accretion came in any sensible degree from the highlands, the quantities deposited from time to time ought to be proportionate to the quantities of rain which fall during the same periods; for the volume of matter brought down from the highlands and carried by the river must be regulated in a great degree by the quantity of water that carried it. But it is a well-established fact that the accretions of sand to be found at the mouth are so much greater when the volume of water is smaller; while in high-water time, when the Nile contains nearly 0.008 of suspended matter, the sand-banks are carried off and distributed a great distance at sea."

We have quoted at length in order to demonstrate at the same time all the force of this system in certain circumstances and its insufficiency in others, particularly in what concerns the Mississippi.

To prove that the system of the formation of bars by the carrying of marine detritus is insufficient to give us satisfactory explanation of the difficulties which surround this vexed question, we have only to remark that the action of the Mississippi is directly opposed to that of the Nile. It is during the season of rains and high tides, when the river carries 1.1153 in weight of matter in a suspended state, that the deposit on the bottom and upon the bars is greatest, which could be easily foreseen, and is clearly explained by the system of fresh-water alluvium. It is at the time when the difference between low-water and high-water marks is 14 feet, in the city, that the bars are most difficult to cross.

As to the carrying away of the bars by a confluent volume of water at high-water mark and their scattering in the sea, it is a question far from being raised.

On the other hand, it is evident that if the accretion of alluvion was caused exclusively by the Mississippi, it would take place from outside to inside the bar, and would tend to extend against the current of the stream, instead of advancing progressively seaward; as, approaching the bar already existing, the current would lose its swiftness and would allow its muddy load to settle inside of the obstacle. Besides, the geological soundings made by engineers of the United States through the sedimentary accretions of the bars have demonstrated the existence of four or five evidently distinct strata, the origin of which runs back to regions of the Gulf, far from one another. Thus one is disposed to recognize in the bar at the Northeast Pass, or Pass à Loure, alluvium proceeding from the Alabama River, and the sands of the Rio Grande can be identified in the strata obstructing the Southwest Pass.

From these apparently contradictory arguments we may infer that these two causes, the river and the sea, concur to form the mouths of the Mississippi, each in its respective limit, and to leave only one principal outlet, perhaps sufficient as an issue to its waters, but too much restrained and irregular for the necessities of an extensive navigation. These two equally powerful causes do not balance each other at any given time. Each has its period of weakness or energy.

The river in ordinary circumstances, that is to say, at low-water mark, or at mean tide, carries a certain quantity of matter, which is distributed in the depth of the liquid mass according to its density, the finer and more diluted mud being nearer the surface.

The swiftness of the current near the bottom being much less than the swiftness of the upper current, the deposit in the bed of the river of all the heavier matter takes place especially when the current approaches the eighty-feet wall which forms the main body of the bar, leaving only an outlet of fifteen or seventeen feet above it. In this outlet the water increases, and being compressed and undergoing the same pres-

ure, it obeys the laws which cause the contraction of the fluid veins. It is not then, therefore, that it deposits the light mud with which it is laden, but carries it out to sea a distance of several miles, and a wide circle indicates the limit where this mud ceases to color the water, and where the sea, after dividing it into minute particles, spreads them afar under the action of winds and currents.

Mr. Charles Ellet recognized at sea the existence of a stratum of fresh water, about 7 feet in depth, floating in the waters of the Gulf without mixing with them; and this phenomenon of two distinct currents manifests itself on the bars, where it is ascertained that under the columns of fresh water there is a counter-current of about 8 feet of salt-water. This new narrowing of the outlet corresponds with a new increase of swiftness, for while the velocity of the river is only 2.6 inches at Carrollton, it runs at a rate of three miles at the surface, and nearly two miles near the bottom, when passing over the bars.

The existence of this under-current combines, with the increase of swiftness we have alluded to, to render impossible any fresh-water accretions during the mean or low-water mark. Thus, during this period of mean and low water, the river carries to the sea all the alluvium the density of which has prevented their deposit in its bed before reaching the passes. Nothing remains on the bars.

It is no longer the same at high-water. Then the outlet is no more sufficient, the river drives the counter-current before it, and its waters occupy the whole passage. But, as its increased swiftness has enabled it to transport more numerous and voluminous materials, these, detained in their course by the friction on the bar, and by the resistance of the sea, settle on and obstruct the bars. Meanwhile the upper current of the river, whose velocity has not been reduced, carries afar in the Gulf all the lighter alluvium, which it there leaves to settle in the depths of the sea. If, while this pressure takes place in the fluid vein, a strong tide or a storm should drive the sea against the pass, the struggle between the sea and the river current, trying to force an issue, plows up and drags away the matter which had deposited itself horizontally on the bar; it disturbs it, and occasions accidental obstruction at high-water mark, and gives birth to those singular phenomena known as mud-lumps.

If the river, during its rising period, partially builds up the bars, either by extending them inward or by adding to their height, the sea regains its superiority during high-tides or great storms; for it piles up new materials at the base of what already forms the outer wall of the bars. These materials are thus, in great part, restored to their former origin; for the greater portion consists of alluvium that the great river had furnished, and it is fortunate that such should be the case. The argillaceous nature of these materials prevents the accretion formed from attaining too much consistence, and resisting the causes of destruction or removal to which they are exposed.

Fortunate would be New York if the vast sand-bank which is gradually invading its port was of a nature so little resisting.

This double and irresistible action of the river and the sea, which we would describe more minutely if it would not lead us too far from our subject, follows and obeys an immutable law of nature, to attempt to change which, by any contrivance of man, would be folly; for the more closely we study its working, the more convinced shall we become that its field of operation is too vast, and must increase rather than remain stationary.

The gradual growth of the obstructions at the mouth of the river, previously referred to, has been and still is accelerated, if not entirely caused, by the system of levees as now practiced on a yearly increasing scale. This system has prevailed over the system of lateral outlets, and, without wishing to discuss at present the wisdom of that preference, we make note of it, and only remark, that the mass of alluvium which formerly deposited itself in accretions on the swamps of the delta now go entirely to the sea. This is doubling the volume of fluvial matter which drifts into the sea; it is, therefore, doubling the materials with which that indefatigable builder will erect the walls of our bars.

On the other hand, as the delta projects itself farther out, the various mouths of the river are left every day more exposed to the action of the winds and currents without protection. It is admitted that any great river that does not empty into a bay capable of protecting its mouths against the action of the winds and waves must soon be obstructed by the formation of bars heaped up by the sea. Such has been the case with the Ganges, the Nile, the Mississippi. It is even necessary that the surface of the bay should be, to a certain extent, proportionate to the volume of water which is discharged in it; if too small, the river does not lose a sufficient portion of its swiftness, and comes out of the bay still exposed to the contrary influence of the waves. The bay in that case is but an enlarged outlet of the river.

If the bay is too wide, the swiftness of the stream is quickly reduced, and its sedimentary deposit fills up gradually the basin in which it discharges itself. Such is the case with the river Clyde. Some hydrographers are of opinion that the vast bay formed by Lakes Borgne and Pontchartrain, and yet called the "Mississippi Sound," was destined by nature to be the real outlet of the river, and that, by closing the out-

lets of its waters in the two reservoirs above and below the city, the natural course of this navigable highway has been completely changed.

Whatever may be the case, the progressive tendency of the delta toward the sea will only increase the incumbering and obstructive influence of the winds and currents. The South and Southeast Passes, henceforth impracticable for ships of ordinary draught, prove that, where this influence is direct and in the course of prevailing winds, its effects are alike prompt and dangerous. The North and Southwest Passes have thus far escaped this action, only because they have been partially protected by their peculiar direction.

Consequently, nothing can be hoped from the natural agents, either in the present or future, to improve the condition of the mouths of the Mississippi. Far from it. We have demonstrated that this condition can only grow worse in the course of time.

Let us now discuss the efforts that have been made to undertake a gigantic struggle against forces that are natural, eternal, and necessary. We will embrace in the same examination the study of the means indicated, but not tried. We will find the result of this examination in the conclusions of the State engineer, Mr. Hebert:

"Let us submit ourselves, not to struggle with the Mississippi. We have no hold over it. Our presumptuous efforts can only result in bringing the punishment on our own heads."

The slightest reflection on what precedes will enable any one to understand that the idea never entered the mind of any practical man to remove and annihilate those immense masses called bars. Let one imagine enormous blocks of mud, having a length of several miles, a width varying from one-fifth of a mile to one mile, and a height of more than 80 feet. Let them be represented propped on the river-side by an abutment which is formed by its bed, upon which the deposits of ages in the untroubled waters have caused such elevation of that bed that its height is 80 feet more than any other point as far up as Baton Rouge, although the mean declivity of its surface is $3\frac{1}{4}$ inches per mile between these two extreme points. In presence of such gigantic obstacles it will be easily understood that all the hope of science and commerce has been limited to the excavating of their upper surface in order to procure an open and permanent way to navigation. Consequently a regular passage of from 3 to 5 feet more depth than actually exists on the bars is the extreme height of the ambition of our engineers and our merchants. But, as modest as may be this ambition, it is necessarily doomed to disappointment, for a sort of compromise has been entered into between the sea and the river, by the slow and alternate poisoning of their opposed forces, by which the necessary outlet for the river has been fixed at a height of 15 to 17 feet. We cannot go beyond this.

The first work for the improvement of the passes goes back as far as 1839. The Federal Government commissioned Captain Talcott, of the Corps of Engineers of the United States, to proceed to the opening of a regular channel. That officer used in his attempt the ordinary bucket-drag; but circumstances were so unfavorable that he obtained no result. In one stormy night twice as much mud was thrown into the Southwest Pass as had been taken away after these expensive labors.

In 1852 the Federal Government made with the Tow-Boat Association a contract for the opening of the passes. This contract was fulfilled, and the work executed in twelve months. The means used by the association were the harrow and the rake, and the result was successful beyond all expectations; a channel was dug 18 feet in depth, and on a length of one and a half miles. This process had already been successfully adopted on several alluvion rivers in England.

As, after this result, no ulterior measure was adopted by which to maintain the Southwest Pass in this prosperous condition, and the causes of the formation of the bar not having ceased to act, the bar naturally very soon became as impracticable as ever to navigation. It was again a dreadful storm that destroyed the work already accomplished.

A new effort was attempted in 1856, but upon an entirely different principle, and based upon a theoretical conception. The Corps of Engineers of the United States thought that, if it were possible to give the river a greater velocity in the locality of the bars, the deposit would be swept off far away, and the passage would remain free, without any necessity for periodical and expensive labors. This solution corresponded with the hypothesis of the formation of the bars by the immediate precipitation of the fluvial alluvion, without taking into account the action of the sea. In consequence, Messrs. Craig and Rightor were authorized, by a contract with the Government of the United States, to open a canal 300 feet wide by 20 feet in depth, in a straight line across Southwest Pass, and a similar canal across Pass à Loutré. The work in both passes was to be completed in ten months. The contractors were, beside, bound to open these channels during four years and a half, to begin from the completion of the work. Subsequently the contract was amended by reducing the required depth of the channels to 18 feet instead of 20, and by granting an extension of time.

The plan prescribed to the contractors was the closing up of all the passes except the Southwest Pass and Pass à Loutré, and the contraction of the current by means of

oblique dikes, made of strong piles, placed at a distance of 5 feet, and connected by boards 5 inches thick, with crowning-boards connecting the heads of the piles to one another.

The work performed in Pass à Loutré began on the north side and extended itself in a diagonal line in the current to a short distance from the bar, and on a length of 550 feet. In the Southwest Pass this breakwater was not over 3,000 feet in length. These enormous expenditures gave no result, and the contractors had to give up the work. But, even had a result been obtained, it could only have been temporary, like everything else that has been attempted to modify the condition of the passes.

The problem of the outlets of the Mississippi had been assimilated to that of the mouth of the river Clyde, where a breakwater made of stakes supporting a stone-work had given excellent results. The assimilation was incorrect, inasmuch as the Clyde is protected at its mouth against the action of the waves by the Forth into which it empties, and that the only cause of its accretion was the too great extension of the Forth, as compared to the volume of water proceeding from the river, which arrested its swiftness and determined the precipitation of the deposits. We will observe, besides, with Mr. Hebert, that any wood-work placed in the waters near the Gulf would be destroyed by the worms in a very few years.

After this fruitless attempt the contractors created, during some time, a navigable channel, by employing the expensive process of blasting. But all this was again made useless by the incessant but silent working of the forces which cause the formation of the bars, and Messrs. Craig and Rightor had to abandon definitely their contract.

Since that experiment, all the science of the engineers who propose to improve the bars is confined to the drag to break up the accretions and carry them out to sea, or to the use of the harrow, to disturb them, confiding to the current the task of carrying them out. In both of these systems, so little different from one another, it is well understood that this work can only be made permanent by means of an annual fund created for this ever-recurring task.

Captain Duncan's plan consists in the purchase of a dredge-boat, costing \$50,000, and operating successively on the two bars during four months each. The calculation of the cost attendant on this work shows, after deducting the cost of the boat, the net sum of \$105,270.

Mr. Hebert opposes this plan for various reasons, which are well worthy of attention. "First," he says, "this work would demand heavy expenses for boat and machinery; and when the mud will have been detached from the bottom it will have to be put in other boats, which will carry it out to sea. Many laborers will be needed, and the process will be very slow. Secondly, while these boats will be employed in the channel, they will incur it in such a way that ships will not be able to pass, and commerce will suffer."

Mr. Hebert's plan, which is based upon the use of the scrapers and the harrow, has not, he thinks, those inconveniences. We cannot agree with him on that point; for the two boats which he proposes for the two passes, and the management thereof, we find, again, an expense of \$150,000, of which \$50,000 will have to be renewed annually. The difference for such an object is not much. As to the presence of a boat in the channel, it seems to us equally troublesome in either system.

But what induces us to embrace both in the same condemnation is the judgment passed upon them by the facts we find in the past. Was it not the drag that Captain Talcott used in 1838 and 1839? A night was sufficient for the destruction of all he had achieved. Was it not by means of the harrow that the Tow-Boat Association opened a temporary passage? A single storm sufficed to fill it anew.

Can nothing better than such uncertain and feeble results be obtained in this enlightened age, for the security and benefit of the immense commerce entering into and issuing from the Mississippi—a commerce already counted by hundreds of millions of dollars, and destined, with proper facilities for the safe and speedy entrance and departure of vessels, to vie with that of the largest ports of the New or Old World in richness and extent? We believe there can; and we shall proceed to examine whether an outlet from the Mississippi cannot be obtained by means and through a way more sure and durable than any that have yet been proposed.

All the investigations hitherto made convince us that we are powerless to improve permanently the outlets of the river, either by acting directly on the passes or by modifying the general course of action of the river itself; and we are again and again compelled to admit that the Mississippi has not, and cannot have, a reliable, adequate outlet at the extremity of its course.

Before we attempt to create another, let us examine the consequences of this proposition on the commerce of New Orleans.

NECESSITY OF A COMMERCIAL OUTLET TO THE MISSISSIPPI.

The free navigation of the river by ships equal in size to those which frequent and supply all great ports, that is, of an average tonnage of 1,000 to 2,000 tons, has always been the hope and the dream of the commerce of New Orleans. The numerous failures

experienced have not yet destroyed that hope, nor have the sad lessons of reality been sufficient to dispel the dream. This illusion has, however, cost dearly to our port. Our commercial navigation offers the singular anomaly of one of the greatest foreign exportation trades on a distance so considerable as the width of the Atlantic, carried on by means of small ships, whose average tonnage does not exceed 692 tons. We will have occasion soon to refer to the deplorable consequences of this singularity.

If at the beginning of our great commercial enterprise, which does not go back to a very remote date, public opinion had been as determined as it is now, concerning the impossibility of opening the mouths of the Mississippi to the navigation of large vessels, the force of circumstances, the encouragement found in the admirable condition of our port, and urgent necessity, would have induced the founders of this community to adopt, at an early date, the only measure that reason points out, and which we want to attempt now. *They would have left aside the passes, and would have a direct outlet from the river.* For the last forty years New Orleans would have been the first port in the United States. New York would have only occupied the second rank. It is not too late to open our eyes to truth, and to act with energy and promptness, no longer to conquer anew a rank that has escaped us forever, but to avoid the consequences of our former and fatal errors. It is now no longer the question of glorious predominance, and of rank to be assumed. The question is to defend our existence, and to preserve for our wharves the produce disputed by unrelenting competition. Our rivals act and create; as for us, we are content with making official reports on the subject, and when these reports uniformly conclude by an appeal to Congress, we wait, with our looks turned toward Washington City.

Previous to the war with England New Orleans had not awakened to her great commercial existence; the greater portion of her commerce found a channel through Lake Pontchartrain and Lake Borgne. When, for the defense of the country, it became necessary for the Federal Government to close those two outlets of the river above and below the city, nothing was left to the latter except the way by the passes. At that early time the clever speculators of New England understood the immense benefits which a navigation that could only be performed through countless shoals, through a maze of reefs whose positions vary incessantly, and where the use of a great auxiliary power was indispensable, would promise to a piloting and towing association. Thus it was that the burdensome exigencies of pilots and tows were imposed upon our newly-born commerce. However, the hope existed, even at that date, that the yoke would be thrown off the day when great works will open forcibly the mouths of the Mississippi. It was necessary to submit to this for the time being, and to conform to it the condition of the commercial navigation. Meanwhile navigation in large vessels was abandoned and ships of small draught were constructed expressly for New Orleans.

At last came those attempts at improvements, so long promised and so impatiently expected. We have seen that they go as far back as 1839, and we have narrated the useless labors of Captain Talcott. During that time the deplorable condition of our navigation called from the shippers of the interior, from our own and foreign merchants, such numerous and energetic complaints that they suggested the idea of a possible competition. This consisted in nothing less than to build, at great cost, railroads on all the width of the continent to meet the Atlantic ports, while the great river, "that moving road," as Pascal calls it, was gratuitously left to us. Moreover, the greater portion of the articles which would have been carried upon these railroads consisted of agricultural products of a comparatively small value and cumbersome nature, for which the question of rapidity was immaterial. It must be conceded that all these motives made the prospect but little encouraging, and that it needed all our infatuation to permit a success so doubtful to all appearance.

Notwithstanding the incomparable superiority of the Mississippi over all other practical routes, the railroad system began to draw an important portion of the produce of the valley of the Mississippi. All the North and a portion of the center belong to them; it is by a net of railroads and by the navigation of the great lakes that the grain from the West and Northwest, the most colossal mass of agricultural products ever thrown into circulation by any country in the world, finds an issue. The time may yet arrive when we can again enter the lists and bring back to its natural route a certain portion of this immense tonnage. This will be when we have a secure outlet for the river with a constant depth of water of 22 to 24 feet, together with a direct communication with Europe in ships of considerable tonnage. To obtain this result, so easy, since it only depends on our own will, it is necessary that the community should be thoroughly enlightened upon the present condition of commerce at the mouths of the Mississippi and the consequences to the prosperity of our city resulting therefrom.

We cannot quote, in this respect, a more instructive document than that we find in the report of the committee of the New Orleans Chamber of Commerce, commissioned to visit the bars in February, 1859. This committee was composed of Messrs. W. Creevy, E. L. Wibray, J. B. Morrison, G. A. Foedick, and P. H. Skipwith.

The amount of merchandise delayed at the bar on that occasion, seeking ingress or egress, was estimated as follows:

1. For exportation.

Cotton, bales, 71,985, at \$60	\$4, 319, 100
Tobacco, hogsheads, 3,337, at \$150	500, 550
Sugar, hogsheads, 2,277, at \$75	170, 775
Molasses, barrels, 1,575, at \$12	18, 900
Pork and beef, barrels, 11,309, at \$18	203, 562
Flour, barrels, 11,417, at \$5.50	62, 793
Lard and ham, tierces, 2,929, at \$30	87, 870
Wheat, sacks, 3,789, at \$1	3, 789
Total	5, 367, 339

2. For importation.

An approximation of value	2, 000, 000
	7, 367, 339

"It will be thus seen," says the committee, "that there is now held in check, in consequence of the impediments to navigation above referred to, property worth nearly five and a half millions of dollars, the interest of which for a single day, at 6 per cent. per annum, amounts to about \$1,000. In this estimate no account is taken of the value of the ships, nor any but the leading articles of produce; nor the cargoes of the ships which have cleared and are ready for sea, and whose commanders deem it more prudent to remain at the wharves until there is a prospect of getting over the bar without difficulty, than to lie at anchor inside or aground on the bar in the crowd of ships, and liable to damage. This is a startling array of figures; in itself sufficient, in the opinion of your committee, to arrest public attention and cause the most indifferent to reflect on the evils likely to arise from such a derangement of the commerce of the city, and which will end in the total ruin of our trade, and even our very existence as the emporium of the Southwest, unless prompt and energetic means are adopted for the removal of these obstructions.

"Much has been said and written on the subject of the railroads which now tap the Mississippi River, and have their termini on the Atlantic shore, and of the injury which they were likely to work to the trade of New Orleans, by diverting the produce of the great valley of the Mississippi from its natural outlet there; but these your committee have read and listened to without the least feeling of alarm, having an abiding confidence that the Mississippi would continue to be the great highway for the produce of the valley which bears its name, and New Orleans the great depot and point of exportation, if there was free communication with the Gulf of Mexico for vessels of the class required by the yearly increasing necessities of trade; but they must confess that the spectacle which presented itself to them at the bar gave rise to grave apprehensions whether or not it would be possible to retain the trade of New Orleans and maintain its position as the greatest exporting city of the Union, unless some measure of relief is speedily granted; nor are the movements going on around us calculated to allay these fears. Already rival cities, taking the advantage of our misfortunes, are putting forth their claims to a share of the trade which has heretofore been ours, and which, we are constrained to admit it needs no prophetic eye to discern, must soon seek other channels unless these obstructions are removed; for your committee do not doubt that every facility will be given by our rivals to those frequenting this port and mart, which their own resources and all the outside aid they can bring in will command.

"In the list of property detained at the bar is comprised one item of nearly 72,000 bales of cotton. Some of these outward-bound ships have been detained for several weeks, and it is hardly to be supposed that parties in want of cotton will again send their orders to New Orleans, if there is the least likelihood of a similar delay in getting it to market; and if this community is not alive to its interests, the now famous cotton mart of New Orleans will speedily become a thing of the past. Again, the bills of exchange drawn against the cargoes so detained will, in all probability, mature before the produce arrives, when, by all ordinary calculations, it would have been at hand in time to meet them, and this is another ramification of the evil which may overtake us in the shape of a derangement of our monetary affairs, consequent upon the difficulties which parties may experience in raising funds to retire the same.

"Of the value of the cargoes of the inward-bound ships your committee have no data, but they think it may be safely put down at two millions of dollars. Many of these ships are laden with goods destined for the West and western trade, and it requires but a slight effort of the imagination to picture the loss and inconvenience which the owners have suffered by having their goods detained until the proper season for their sale

is past. These, again, are not likely to order their supplies to be shipped via New Orleans until they have the assurance that these impediments to the navigation have been permanently removed. In looking at the question from this point of view, we can see the interest of the consumer, although apparently remote, is actually near and positive. So large an amount of goods being kept out of market, must necessarily enhance the value of those on the spot, and he therefore has to contribute his quota of the loss by the advanced prices which he has to pay for the articles of import which he requires."

One month after the visit of the committee of the chamber of commerce, the State engineer, Mr. L. Hebert, and his first assistant, Mr. L. J. Fremeaux, arrived at the passes to prepare their report to the legislature.

On the 3d of March, they found three vessels aground on Pass à Loutré; one of these, the Mary R. Campbell, drawing 19 feet, had been aground sixty days; another, the Avon, drawing 16½ feet, was on the bar since the previous day; and the third, the Lebanon, drawing 17½ feet, had been there three weeks. The previous day a large ship, the Lancaster, that had been aground forty-eight days, had been at last pulled out of that unpleasant fix. Vessels thus remain on the bar because of the tortuosities of the channel. Each vessel that runs aground causes a diversion and a separation in the current, and consequently the formation of other secondary bars. The strongest tow-boats cannot follow the channel in all its irregularities, and thus it is that they run aground vessels drawing less water than there is in the channel.

Arriving at Southwest Pass on the same day, 3d of March, Engineer Hebert found at anchor, inside of the bars, thirty-five vessels awaiting the possibility of egress. There were also three on the bar and seventeen outside, at anchor, awaiting to be towed in. There were then altogether fifty-five vessels detained. Here are some interesting documents concerning thirty of them:

Names of vessels.	Draught.	Days of detention.
	<i>Feet.</i>	
Bullion	16½	8
Fanny Forrester	18	24
J. Montgomery	17½	9
Bessel	18	24
Saint Louis	16½	3
West Point	18	3
Bannockburn	17½	10
Potomac	17½	12
Creole	17½	1
Wm. Lord, jr.	18	15
Aran	18½	7
E. Merson Smith	18½	7
Bamberg	18	22
Mary	18	22
J. Morten	18	25
Huntress	18	15
Levi Woodbury	19	26
Sheridan	18½	22
Athena	17½	10
Barnabus Webb	19½	29
Lockinvar	17½	8
E. F. Gabain	19½	39
S. E. Pettigrew	19	26
Ch. Davenport	17½	1
Victory	18½	9
Arctic	18½	2
Lady Sale	17½	1
Ocean Monarch	19½	5
Wm. Stetson	18½	1
Czar	17½	3

"Between the 28th of February and the 3d of March, at 3 o'clock p. m., a few of the above-named ships were taken to sea, but others had been brought from the city, and, as before stated, there were on the 3d of March outward bound thirty-five vessels. Two of the ships on the bar were much in the way. The Tow-boat Association are busy bringing in and passing out vessels, but they have more than they can do, on account

of the immense power they are compelled to use, and the long time they have to give to each ship. With the large number of vessels now detained, and those that are constantly arriving, there would seem to be no end to the work the tow-boats have before them."

One more quotation, taken also from an official source, will be sufficient to prove that the commerce of our city suffers from the present state of things. The committee of the legislature on commerce and manufactures closes as follows its report of the 3d of March, 1859:

"In conclusion, we beg leave to call your attention seriously to the present condition of the bar at the mouth of the Mississippi River, which, at this time, cannot be crossed by a majority of vessels coming in and going out, without great labor, cost, and delay. We further call your attention to the enormous amount of appropriations from the General Government which have been expended in attempts to remove this obstruction, without any benefit whatever. We therefore recommend, and hope your honorable body will take immediate steps to present this state of affairs to Congress, and urge action on the part of the proper authorities."

Independent of the inconveniences enumerated above, some others exist that result from the very position of the mouths of the delta, and their stretching out in the main esca.

Their approach is surrounded by difficulties; no shelter protects the vessels against the winds and waves, and the large number of shoals that are found in their vicinity renders the service of a pilot indispensable.

During at least eight days in the month in the winter season fogs prevail of such intensity as to render ingress or egress impossible. Engineer Hebert mentions this obstacle in his report of the 9th of March. Speaking of his arrival at the passes on the 28th of February, he says:

"Here I encountered such heavy and constant fogs that, although I ran from pass to pass, taking notes of the shipping, steamers, &c., it was only on the 2d and 3d of March that I could make the examination of the bars."

Moreover the necessity of towing carries with it, as a peremptory consequence, frequent damage, and an extraordinary rapid wear and tear of the vessel. The effect on a ship's hull of the traction of one, and sometimes several tow-boats, pulling her, and making her force her way through a muddy mass, whose surface is generally soft, but which is sometimes hard at a depth of 18 inches, may be easily imagined. We have seen on the 3d of July last, at the Passes à Loutre, four tow-boats hitched to a single vessel, and applying to her four different angular forces. Each of these tow-boats was of at least 400 horse-power; the ship's draught was only 17 feet 8 inches.

Finally, the cost of this so destructive auxiliary force is exorbitant, and while it makes the fortune of the rival companies that carry it on, it burdens our port with a tax exceedingly onerous in our competition with Atlantic ports. It can be estimated at 83 cents per ton for vessels of small tonnage; a ship of a thousand tons pays for towage up and down the river \$1,043, and must bear an additional charge of \$150 if compelled to take a second tow-boat to cross the bar.

Official documents estimate the tax levied by towage and pilotage on the commerce of New Orleans at over \$2,000,000. And this tax has for its only result to prolong an expedient which compromises our present and future existence.

Let us recapitulate the various charges in an act of accusation which might be made by the commerce of New Orleans against the navigation of the passes. The access to the passes is difficult and dangerous. It is unprotected and exposed to every wind. Pilotage is of imperious necessity. The condition of the passes makes it necessary to employ tow-boats, the use of which is as ruinous to the solidity of the vessel as it is expensive.

The tow-boats themselves are of insufficient number to meet the necessities of navigation; besides, they cannot bring over the bars with anything like regularity ships drawing more than 16 feet.

The vessels thus detained on the bars are exposed to damage, the risk of which augments greatly the rates of insurance.

During all the time of their detention there is a loss to the ship-owners in interest on the ship's capital, in the decrease of an annual circulation of this capital, and in the increase of the crew's wages and consumption of stores. The tardy arrival of his merchandise in the market destroys all the favorable chances of speculation of the shippers of the cargo, the merchandise is exposed to deterioration by the decay, and he runs also the risk of seeing his drafts on foreign markets returned to him protested.

All these causes of complaint fall back upon the merchants of New Orleans, by depreciating our market, and causing our customers to send their orders to other markets, where they are sure to be filled with certainty and promptness.

The committee of the chamber of commerce was, therefore, right when it stated that New Orleans could only preserve her position as the great mart of the Southwest

on condition that a free communication with the Gulf of Mexico be established; *now this free communication does not and cannot exist through the passes.*

The committee adds that this facility of communication must exist for ships of the class claimed by the ever-increasing wants of commerce. This judicious remark leads us back to that which we made on the singular character of the commercial navigation of New Orleans, giving rise to one of the greatest shipping enterprises in the world, that of American cotton to Europe, across the Atlantic, in ships of comparatively small tonnage and slow speed.

We have explained how the state of the passes had imposed these hard conditions upon us. We will state the facts by means of the official figures furnished to us by the statistics of the business of the port.

1.—EXPORTATIONS.

Year.		Vessels.	Exported tonnage.	Tonnage.	Value.
1858-'59	American vessels to foreign ports ...	834	Exported tonnage.	641, 392	\$101, 634, 952
	Foreign vessels to foreign ports ...	336	do	167, 964	
	Coast trade	1, 015	do	409, 872	
	Total	2, 185	do	1, 219, 228	
1859-'60	American vessels to foreign ports ...	958	Exported tonnage.	713, 548	106, 393, 567
	Foreign vessels to foreign ports ...	334	do	180, 733	
	Coast trade	943	do	354, 905	
	Total	2, 235	do	1, 248, 526	

2.—IMPORTATIONS.

Year.		Vessels.	Imported tonnage.	Tonnage.	Value.
1858-'59	American vessels from foreign ports.	694	Imported tonnage.	492, 522	\$16, 678, 092
	Foreign vessels from foreign ports...	345	do	167, 598	
	Coast trade	1, 024	do	521, 972	
	Total	2, 062	do	1, 182, 092	
1859-'60	American vessels from foreign ports.	696	Imported tonnage.	452, 310	20, 634, 393
	Foreign vessels from foreign ports...	328	do	178, 286	
	Coast trade	1, 028	do	575, 433	
	Total	2, 052	do	1, 212, 029	

Total number of vessels circulating across the passes has therefore been 4,247 in 1859-'59, and 4,287 in 1859-'60, both for exportation and importation, and the total tonnage has been 2,401,310 tons in 1858-'59, and 2,460,555 in 1859-'60.

The comparison of these two years gives us an average of 565 tons per vessel for the preceding, and 574 tons per vessel for the current, year.

But if we examine especially the exportations to foreign ports, we find in 1859 1,170 vessels exporting 809,356 tons, which gives us an average of 692 tons per vessel. In 1850 there were 1,292 vessels exporting 894,321 tons, making again an average tonnage to foreign ports of 692 tons.

It will be seen that this tonnage, so small when compared to that of Atlantic ports having vessels of 1,200, 1,500, and 1,800 tons, is required by the nature of the outlets of the Mississippi. In fact, it can be admitted as an average that a vessel of 600 tons draws 14½ feet of water; one of 800 tons draws 16 feet of water; one of 1,000 tons draws 18½ feet of water; one of 1,200 tons draws 20 feet of water; one of 1,500 tons draws 21 feet of water. Can such a state of things continue at a time when it is demonstrated that the greatest profits are earned by the largest ships?

It is evident that, due allowance made for proportion, large vessels cost less to build than small ones; they take less materials, secure a greater economy in the general expenses, and are faster and safer. All possible advantages will then be found in substituting large vessels for small ones wherever the natural conditions of navigation will permit this change. As for ourselves, until we shall have created an outlet to the Mississippi, with a regular depth of 22 to 24 feet, we will find it impossible to realize this progress.

Ships of a large tonnage may, it is true, run the same disadvantageous chances as smaller ones, such as returning in ballast; but an examination of the preceding statistics shows that the difference between the tonnage of exportation and importation

is small, and that the difference will diminish as soon as the direct trade of large ships between our port and Europe will compel those ships to bring to us directly, in order to make their return cargoes, those articles of importation which we are now receiving indirectly and by the way of the North.

If the value of our importations be compared to that of our exportations, the following results will be found:

In 1858-'59, importations, \$16,678,092; exportations, \$101,634,952; difference, \$84,956,860. In 1859-'60, importations, \$20,634,393; exportations, \$108,393,567; difference, \$87,759,174. Now, in 1858-'59 we received, in specie, \$15,627,017; and in 1859-'60 we received, in specie, \$8,444,857. There is, therefore, a balance in our favor in 1858-'59 of \$60,329,844, and in 1859-'60 of \$79,314,317.

This balance is refunded to us from abroad in the shape of merchandise exported to the North, which makes good use of it in the settling of our accounts with the interior, thereby making double profits—first, as brokers between Europe and ourselves; and, secondly, between us and our customers of the interior, without counting their profits as ship-owners and freight-carriers.

From the day that a free access to our port will permit a large direct trade with Europe, this balance will in great part come to us directly, and it is from our wharves that the distribution of these goods will be made; the mean value of the ton of imported goods being \$14.11 for the year 1858-'59, and \$17.02 for 1859-'60, while the value of exported goods per ton is \$83.36 for 1858-'59, and \$86.82 for 1859-'60. There will be a business of importation equal in value to about that of exportation, but of fourfold tonnage.

Then it is that, to furnish return freights to this increased number of arrivals, we will have to struggle in our turn to get back a portion of those agricultural products of the West which the Northeast has attracted to its ports by its railways; but then we will have conquered new advantages, and, being able to offer to those products an easy and regular outlet, a direct transportation to Europe, and ships of a large tonnage, we will find ourselves engaged in competition altogether advantageous to us. The railroad interest of the North already feels this. To sustain their roads it has been found necessary to increase the tariff, and under this increase of freight we find the following results in the comparative transportation of a cargo of 3,000 barrels of flour shipped from Cincinnati to Liverpool by the way of New York and by the way of New Orleans:

From Cincinnati to New York, \$1.75 per barrel.....	} \$2 25
From New York to Liverpool, 50 cents per barrel.....	
From Cincinnati to New Orleans, 50 cents per barrel.....	} \$1 46
From New Orleans to Liverpool, 96 cents per barrel.....	

Difference in favor of New Orleans, 79 cents per barrel.

This difference will be still greater when our trade will be direct and carried on in large ships, and independent of the passage over the bars and the attending charges.

CANAL BETWEEN THE MISSISSIPPI AND THE GULF OF MEXICO.

Section 1.—General conditions.

The Mississippi has no outlet adequate for its commerce, and it is important that one should be created without delay. These are the two propositions we have demonstrated. We have now to describe this artificial outlet, and to study it with the attention which its importance deserves.

Let us specify, first, the conditions that it must satisfy.

1st. It must free navigation of all the difficulties which surround the mouths of the river; it must, therefore, be at a certain distance above the passes.

2d. It must not lengthen the term of navigation in the Gulf of Mexico, a sea so dangerous and exposed to gales. It must, therefore, admit the vessels in the river as near as possible to its mouths.

3d. It must not, moreover, be too far from the natural mouths of the river, in order not to create too great a difference of level between its point of junction with the river and its junction with the sea.

4th. It must be placed at a point on the river where there exist no battures and no fairs of battures forming subsequently.

5th. It must be on the shortest line between the river and the sea, on condition, however, that this advantage shall not be compensated by a considerable increase in the expenses.

6th. It must present, at its opening on the sea, natural shelters to protect the approach of vessels.

7th. It must, besides, offer a direction little inclined with that of the wind prevailing during the greater part of the year.

8th. It must open on the sea at a point where no accretion and no decrease in the present depth of water are to be feared.

9th. It must offer to vessels secure anchorage, so they may lie in safety outside the canal.

10th. It must free vessels from all necessity of pilotage, and, consequently, avoid their circulation among the islands, keys, and reefs, which in the passes require the services of a pilot.

11th. It must also do away with the necessity of towing, at least as far as the river, where the wind often permits vessels to ascend directly from the English Town as far as New Orleans.

12th. It must have a constant depth of 22 to 24 feet of water, in order to permit the access to the river of ships of the greatest tonnage.

13th. It must be forever secure, by its conditions of existence, from those perturbations which render the passes impracticable to the navigation of large vessels; that is to say, from the action of the sea, from accretions from the river, from sand-banks formed by any agency.

It will be seen from the description we are about giving of the proposed canal, and from its topographical conditions, that it will satisfy, strictly and precisely, all these exigencies.

Section 2.—Topographical and hydrographical description.

When, going down the Mississippi, we arrive at Fort St. Philip, we see the majestic course of the river developing itself on a length of eighteen miles, as far as the head of the passes, without sinuosities or turns. The mass of water moves always in the same direction, without any sensible inflection in its banks. But as the current came from the southwest, and has infected to the southeast from the bend of the forts, the result is that its greatest swiftness and depth are near the left bank, while the water is smoother and deposits its accretions near the right bank. From three to eight miles below the fort repeated soundings have given us depths of 24, 25, 26, and 28 feet, at a distance of 20 and 25 feet from the bank; 20 feet farther the head sinks to 62, 71, and 87 feet.

If we stop seven miles below Fort St. Philip, that is to say, precisely on the 90° 31' longitude west, we are at a mean distance of twenty-seven miles from the passes, which, from the declivity assigned to the river, to wit, 3½ inches per mile, would represent a difference of 7½ feet in the level from that point to the surface of the Gulf. Levelings made by us between this point and the Gulf show that it is only 3 feet higher than the Gulf at mean tide. It is therefore possible to shorten the navigation of the river twenty-seven miles at this point, having to make up for a difference of only 3½ feet declivity at mean water, and 7 feet at the highest water-mark.

This point being chosen at the head of the canal fulfills completely the first three conditions mentioned above. Let us see if it can satisfy, equally, the others.

If from the top of one of the few huts to be found on that bank, upon which, from Fort St. Philip to the sea, there exists no important establishment except the salt-works opposite the Jump—if from this observatory we turn our back upon the river and we look around us, we will see, extending indefinitely to the horizon, a scene of extreme monotony. The left bank of the river from the fort to the head of the passes is a mere neck of land hemmed in between the waters of the Mississippi and those of the sea. Its width, except at few points, does not exceed a mile, and at other points it is narrowed down to a few arpents. An additional mile may be considered as a dependency of the main-land, although cut up in every direction by canals, lagoons, and bayous of an average depth of 2 or 3 feet during tide-time, and which are transformed into mud or sand-banks during low tides. Beyond this is a series of small bays from 3 to 8 feet deep, and studded with a quantity of islets, between which the sea opens deeper passes or deposits accretions upon which numerous oyster-banks are formed.

On the right, on the east line, one of these islets, Bird's Island, of more importance than the others from its length, runs from north to south a distance of four miles; on its eastern point a watch-tower has been built, which commands a view of the sea. Going up from east to north, a long sandy beach, known as Sand Island, forms the limit of these low lands.

In the direction of the northeast, the last of these islands, called the Pavillon Island, fronts an island situated six miles off at sea, and to which we will have occasion to refer; it is Breton Island.

To the left of this islet another neck of land, called the Hard Batture, runs out to meet an island, two and one-half miles long, Grandes Coquilles Island, which is in the due north point, and is only separated by a channel from the smaller Coquille Islands connected in low water with the main-land of Fort St. Philip.

It is, therefore, in this semicircle, the center of which we have placed on the river seven miles below Fort St. Philip, and the circumference of which runs from the southeast to the northwest, that a real archipelago of islands and of lands cut up by lagoons and bays, but uniform in their aspect and their nature, is comprised, evidently created by sea-deposits, but with materials furnished by the Mississippi; they reveal to a geological study the character of the marly accretions to be found in all the deposits of the river. The bottom of the bays and lagoons, covered at certain points by a soft mire which has not yet hardened, is everywhere else perfectly hard, and the purest clay

sticks to the lead. All these lands, scarcely out of the sea, and which it covers in its usual tides and destroys or tears up in its angry moods, only offer to the eye the monotonous vegetation of sea-weeds, gramineous plants, and mangroves.

The radius of this semicircle, from its center on the river to Pavillon Island, is of six miles. It is on this radius that the projected canal runs. It cuts first the two miles of solid land, crosses the large bay in that part of it where the water is lowest, crosses a prairie one mile wide, and, pursuing its course through lagoons and mud-banks, it reaches Pavillon Island, having its outlet in the pass of Breton Island.

It may appear singular that we should have chosen this point of the coast when we have already stated that three miles below the salt-works the neck of land has only a width of a few arpents between the river and the sea; but a simple reflection will justify this apparent contradiction. The object in view is not simply to cut the canal to the sea, which may be done by cutting through a length of 1,000 feet, but it is to open it on the deep sea, that is, at a point where large ships drawing 22 to 24 feet can have easy access. Outside of the main-land there is a border of batture, which in some places projects twelve or fifteen miles, and beyond this batture, whose conventional line is at a depth of 12 feet, the declivity is sometimes so small that a long distance must be made before the necessary depth of water can be met.

The distance of six miles which we have found for the line of the canal is the shortest between the river and the deep sea that can be formed from the forts to the passes, and it is even necessary, in front of Pavillon Island, to dig and continue the canal through a batture for a distance of 3,000 feet to arrive at the required depth.

Another circumstance, altogether exceptional, militates in favor of this side. Hydraulic works or works of embankments made in 2 or 3 feet of water may be considered as made on land; while those made in 8 or 12 feet of water are extremely difficult and expensive. Now, on the line indicated, about three-fourths of the passage are made on the land, and for the other fourth, the average depth of the sea does not exceed 2 feet. This plan combines, then, the advantages of the minimum of distance and the minimum of cost.

Let us examine the access to the canal from the seaside:

We have already said that by following the northeast line, which is that of the canal, there would be found on the main sea, and at a distance of about six miles from Pavillon Island, an island known as Breton Island. This island, which had formerly a length of six miles, and was then occupied by a colonist living with his family in the midst of the vast Gulf, was cut up by a sea-storm that took off from it an islet of half a mile in length, on which a watch-tower has been raised, which would be replaced by a light-house. As cut up as it is, this island, with the batture that extends on its right and left, has a length of ten miles, running almost straightly from east to west, and forming consequently an excellent shelter for vessels against north and northeast winds.

The coast of the river above the fort, and the large peninsula of Lake Borgne, afford protection against the northwest winds.

The coast of the river below the fort shields the canal from southeast winds.

Finally, the south winds are intercepted by the large eastern opening of the delta.

The head of the canal is therefore exposed to the east wind alone, and it is precisely this wind which will bring the vessels from the main sea; it can only facilitate their arrival and bring them in a direct line to the port.

The direction of the canal being northeast, it will be seen that the ships with an east wind will sail directly for the canal with the wind over the quarter, a very favorable direction indeed, both for facility of manœuver and speed. The pier that terminates the canal opens in a semicircle, to afford ample and convenient room.

The existence of natural shelters being thus established, can we depend equally upon the depth of water in the channel formed between Pavillon and Breton Islands? It is principally that point which we have investigated.

Besides numerous soundings in all that region, represented graphically, we have inserted in the plans the series of soundings from the head of the canal to the watch-tower on Breton Island. This line consists of the following points: 26 feet, 36, 35, 36, 39, 34, 19, 14, and 12. These last three soundings are in the vicinity of the batture of Breton Island, the former occupying a breadth of four miles. We have also (although it was one mile north of the canal, and consequently of no great importance) determined a second line from the most advanced point of the reef of Breton Island and of the island of the Hard Batture, where that pass is narrowest, and we have found the following figures: 21, 36, 32, 28, 32, 32, 36, 10. It will be seen that ships will have certain access to the canal with fully sufficient water.

But, with the continual changes made by the Gulf in that region, is there no fear of the future creation of obstacles, such as those that obstruct the passes of the river? We will reply to this query first by arguments, then by facts. It is very true that the tendency of the sea is evidently to fill up all its eastern portion along the river, and to fill up gradually all the lagoons so as to form them into main-land. If it destroys accidentally, it creates constantly, and for this very reason certain passes must necessa-

riety remain where the swiftness, and consequently the depth, will increase instead of diminishing. Such is the case with the two passes that exist west and east of Breton Island, that is, on one side between that island and the promontory caused by the canal, and on the other between that same island and the great batture which begins at Grand Gosier Island and serves without interruption as a basis to the archipelago of the Chaudaleur Islands. It is by these two passes alone that communication can be obtained between the Gulf and the Mississippi Sound within one degree of longitude.

So much for arguments. As to the facts, the comparison of the soundings made in 1827, and consigned on the fine map of the Gulf of Mexico, by Mr. Edmund Blunt, with the soundings made by us, prove that the depth of water has increased in the west pass of Breton Island since that time. These first soundings give 36 feet only on one point of the coast; everywhere else they give 18 and 24 feet.

Among all the advantages we have pointed out in this predestined locality, there is one that we have mentioned too concisely, and which plays too important a part that we should not dwell upon it now. It is the nature of the sea-bottom and of the soil of the island which the canal will have to cross. Reiterated geological soundings that have uniformly given us 14 feet of sand-clay enabled us to verify that it is impossible to find a species of clay more firm, more homogeneous, and more resisting. The anchor bites freely, and once imbedded in it, runs no risk of dragging. The vessels are, therefore, certain of being able to lie at anchor outside of the canal as long as may be desired, under shelter of either Breton Island or Bird Island.

The precious quality of this soil will be again evident when we take up the question of construction.

These general conditions once determined, their consequences may be drawn naturally. The vessels arrive from the high sea into a sort of gulf, opening due east, and circumscribed to the south by the northern bank of Pass à Loure, to the west by the river and Bird Island, and to the north by Breton and Grand Gosier Islands. *In this gulf cannot be found a rock, a reef, or an islet. Its depths vary in the mean line 90 to 36 feet. The light-house on Breton Island and that on the pier of the canal will point out the entrance to the latter. There will be, therefore, no necessity for pilots; no port will ever have an easier and more direct access.*

It is useless to add that, until their entrance in the canal, the ships will have no need of tows. Once in the canal, the towing will be performed by means of locomotives running on a railway built on the top of one of the levees. It is, therefore, only after their arrival in the river that the ships will, if the wind is not favorable, employ tow-boats to ascend the river.

Of all the conditions we have set forth as necessary to an artificial opening of the Mississippi, two yet remain to be fulfilled, the creating of a depth of 22 to 24 feet, and the assurance that this depth cannot be altered or reduced by either the sea or the river.

These two conditions do not depend on topographical or hydrographical data, but on the construction of the canal itself.

Section 3.—*Draught and construction.*

It may be asserted with confidence that no work more important in its consequences has ever presented fewer difficulties of execution, and involved less cost, than the canal of which we have demonstrated the necessity. Consequently, its description need not be long nor complicated.

First, the difference in declivity between its two extremes is of 4½ feet; the difference of level between the waters of the river and those of the sea is only of 3 feet, in ordinary conditions. When the river rises, the sea may be below the level of the river as much as six feet.

The slope of 4½ feet on the horizontal line is almost entirely level from a distance of 3,000 feet from the river; it is therefore reclaimed by a single lock, and outside of this the canal may be considered as being perfectly level. But for the necessity of protecting the talus against the surf of the sea, there would be no necessity for another sluice at the other end.

It is an entirely level country, with no obstacles to overcome, no trenches to be made, no rivers to be crossed, no excavations to be made. Its alimentation presents no difficulties; no fears need be entertained of filtrations or leaks occurring, save those that might affect the solidity of the work. It is in truth a gigantic ditch, unsheltered, perfectly rectilinear, and of complete uniformity on a length of six miles. It will be a great undertaking only by its dimensions and its results.

To determine these dimensions we must remember the object of the canal, which is to open a large road to sea-navigation, to ships and steamers of the greatest size; to continue in some way the draught of the deep sea and of the river without sensible interruption.

But few examples of analogous works can be consulted by way of comparison, and

among them only one has been executed, another is now in course of execution; the two others are as yet but projects.

Canals.	Length.	Width at water-line.	Width of bottom.	Depth.	Number of sluices.	Width of sluices.	Length of the locks.
	Miles.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
Caledonian Canal.....	21	110	50	20	24	40	173
Canal of the Isthmus of Suez.....	90	300 to 195	208 to 103	23	2	63	300
Canal of Nicaragua, (Garella's project).....	.....	134	.....	21	.....	.....	.....
Canal of Nicaragua, (Napoleon's project).....	82	147	.....	23	32	47	210
Canal from Mississippi River to the Gulf.....	6	100	30	24	3	80	400

We owe some explanations on the remarkable differences presented by the dimensions proposed by us compared with the others in the above table.

The prevailing thought in our mind has been to leave free scope to the creations of the future, and, while remaining within the limits of what is possible and reasonable, to give a wide margin to the already manifest tendency to constructing very large ships. Therefore, for all the dimensions claimed for their admission, we have gone beyond the given corresponding figures for the other canals; 24 feet draught at low water; 400-foot locks; 80 feet of openings to the sluices. We have taken as a basis for these speculations on the future the dimensions of the largest steamer ever constructed except the Great Eastern. The Adriatic has a length of 345 feet and a width of 75 feet outside the wheels. She draws 23 feet of water, and measures 4,144 tons.

The Great Republic, the largest sailing-vessel existing, draws 23 feet and has a length of 302 feet and a breadth of 48 feet.

Some time will elapse before New Orleans can see vessels requiring such outlets arrive at her wharves; but, at all events, if such should come, she will be able to admit them. However, there is a figure for which we have remained far below the large sea-canals; it is that of the width of the canal. It is only 100 feet; that is ten feet less than the narrowest of these canals, the Caledonian Canal.

It must be known, first, that the Caledonian Canal, however small its section, gives access to the largest merchant-ships and to steamships and propellers of a large tonnage. Moreover, in its length, which is of fifty-nine miles, comprising thirty-eight miles in Lakes Lochy, Oich, and Ness, there is much circulation in opposite directions. It is, then, necessary that two large ships should be able to pass each other. The same condition exists in all other canals mentioned.

Such is not the case with our Mississippi Canal. Circulation there can only take place in one direction, according to whether the towing locomotives are going from the river to the sea or from the sea to the river. By this combination there is a gain of one sluice, and for a long time to come circulation will not be rapid enough to require other means. Thus a convoy of ships arrives from sea and enters the neck formed by the two piers. The locomotive takes hold of it and tows it to the nearest or seaward sluice, which opens, and the convoy enters the locks. The gates of the seaward sluice close; those of the head sluice open; the level is formed and the convoy enters the river. Then the vessels, awaiting at the wharf on the river, avail themselves of this leveling to enter in their turn into the canal, and they are towed to sea.

The result from this system of working is that the width of 100 feet in our canal is equivalent to a width of 200 feet in canals where ships meet and cross each other. Let us add here, moreover, that toward the center of the canal will be found a basin 600 feet long and 200 feet wide, to be used as a wet-dock.

It will be easily understood that this system would have been impossible had the canal had a greater length. The time necessary for the towage would have occasioned too much delay to ships awaiting ingress or egress.

According to the table already quoted the movements of import and export nearly balance; there were, in 1858-'59, 2,062 arrivals and 2,185 departures, and in 1859-'60, 2,052 arrivals and 2,235 departures.

In the month of November, when this movement was most animated, 267 vessels arrived, to wit, 152 ships, 40 barks, 18 brigs, 29 schooners, and 28 steamships. This gives an average of 9 per day, and as many departures. By doubling these figures the result would only be 18 ships in each direction, or a daily circulation of 36 ships, which, by taking the average of 574 tons per ship, would give 20,664 tons.

The time necessary to cross the two sluices being about fifty minutes, it will take the locomotive one hour and ten minutes to take the vessels and run the six miles. This moderate speed has for object not to injure the embankment; each trip will then occupy two hours.

At the rate of twelve trips per day it is three ships, or little over 1,700 tons per trip.

Nothing can be more practicable than these calculations, although they correspond to a circulation double of that which takes place at the time of the year when the commercial movement attains its maximum.

If we follow the plan of the canal in its short and simple line from the river to the sea, we will find at its head, on the Mississippi, a light-house placed on the upper embankment; the object of this light-house is to point out to ships coming down the point where they must stop. There is to be formed from this embankment, running to a length of half a mile, a wharf, along which the ships and tows they may need will line themselves. Behind the wharf, and at the head sluice, is placed the house of the keeper of the canal and the custom-house office; opposite, on the other side of the lock, is the building used as the locomotive-depot, and containing a machine-shop and a store-house for the urgent repairs and supplying of the vessels.

The head sluice, of a width of 80 feet, gives entrance into a lock 400 feet in length, closed by the middle sluice; the latter gives passage into a channel formed by levees in embankments. From this point the shape of the canal is uniform as far as the sluice at the sea-head.

This profile presents a section 100 feet wide at the low-water mark, 24 feet deep, and 30 feet wide at the bottom. The slope of the banks or talus is, therefore, on each side, of 35 feet base for 24 feet height; that is, about $1\frac{1}{4}$ to 1, corresponding to an angle of 32° . This easy slope is more than sufficient, with the compact nature of the soil, for the preservation of the bank.

On the right and left of the water-line a berme 15 feet wide is formed; it serves to receive the falling-in that might occur in the upper levee, and also to increase the strength of this levee and consolidate its base.

On each side of this base rises the levee formed with the earth from the canal. It is 10 feet high, and consequently meets the upper level of the lateral walls, the brick-work of which is 34 feet above the bottom of the canal. The width of the levee at its top is 15 feet, and for its greater solidity it will have sixty feet at its base; it is a slope of 49, corresponding to an angle of 20° .

On the lower levee (in relation to the river) the railroad for the towage of the ships is built. Two turning-tables, situated at the two extremities of the line, permit the direction of the locomotive to be changed.

From the middle sluice the canal runs a distance of 13,880 feet in main-land on a level. It is a prairie, cut in the last mile by a few unimportant lagoons. It crosses then the large bay on a width of 5,600 feet. It is during this passage that it spreads out in the basin that we have mentioned. This basin will be used as a wet-dock for the dredging-machines, for the boats employed in the service of the canal, and for the vessels which, for some reason, would need to stop on their way. Coming out of the bay the canal runs 4,000 feet through a prairie; it runs again into a series of lagoons of 3,000 feet, gains land once more for a distance of 2,600 feet, and finally crosses a last bay of 1,900 feet to arrive at Pavillon Island, which it cuts upon a length of 400 feet.

It is on the outer shore of this island—that which faces the sea—that the pile of masonry intended to contain the seaward sluice is constructed. There, also, will be the house of the keeper of the sluice.

The two arms of the lateral embankments of the sluice on the sea-side form the head of the double pier, which, starting from this island, run out in the deep sea in the direction of the axis of the canal for a distance of 3,000 feet, where the depth of 24 feet at low-water is found. These two piers, between which it will be necessary to excavate the batture, are the only works of art in the canal. And this work can only be looked upon as a feeble specimen of analogous works conceived or executed by modern science. Thus the dike at Cherbourg has 11,300 feet of length, in depths of 44 feet of water.

The pier of Plymouth has over 4,000 feet in 34 feet of water. The dike in the Bay of Delaware has 3,600 feet in a depth of 42 feet; that destined to form the port of Peluse, for the entrance to the Suez Canal, will have 18,000 feet of development until it attains a depth of 24 feet.

The south pier, on which the railroad will be built, will terminate at its end by a large mole of 100 feet diameter, in the center of which will be placed a light-house with lenticular apparatus.

The description gives a complete idea of the canal. We have now to show how the depth of 24 feet which we have given it cannot be subject to any change, either in increase or decrease.

The increase in the depth would have the inconvenience of undermining the foundations of the masonry or the base of the embankments and produce a caving in. This danger is not to be feared on the river-side. It will be seen that its waters scarcely penetrate in the canal; it could, therefore, only exist from the sea-side; but, when the sea threatens, the outer lock is immediately closed and the whole channel is as smooth as a pond. As to the bottom of the lengthening of 3,000 feet situated between the two piers, its depth and its shelters are such that the sea will remain smooth there at all seasons.

There remains the otherwise dreadful danger of a reduction in the depth; that is, a

reduction in the 24 feet depth originally given to the canal. Then, again, the cause would exist either in a bar formed at the entrance of the canal in the sea, or in alluvions deposited by the waters of the river. As regards the sea, we have seen that the canal opens on the west pass of Breton Island, at a point where the waters of the Gulf becoming compressed increase in speed, and rather tend to deepen their bed instead of filling it. This circumstance is sufficient to prove that the sea, instead of forming a bar at the entrance of the canal, would, if a foreign agency created one there, take it crosswise and sweep it off.

Can we feel as secure on the river-side? The waters as they enter the lock bring at each sluice-full a volume of 14,400 cubic feet, representing about 85 cubic feet of earth. It is apparent that with twelve sluice-fulls per day, the progressive filling up of the canal might be feared, but a very simple disposition, sanctioned by experience, enables us to avoid this inconvenience. A gate made in the center of the laterals forms the opening to a vault which crosses the thickness of this mason-work and opens on a discharging canal. The sill of this door or gate is on a level with the water-line of the canal, and it is closed when the waters of the river enter the lock. So soon as the level is established between the lock and the river, and when the ships have passed from the river into the lock, instead of opening the gates of the middle sluice, this lateral gate is opened; the river-water, which, from its lesser density, has in great part floated upon the salt water, runs out by this outlet, and the gates of the middle sluice are only opened when the level has come down to the water-line. By this means the waters of the river only penetrate into the channel in very trifling quantity.

Besides, if any accretions were formed in the channel or in the locks on the river-side, it would be sufficient to take advantage of the season when the river being at a low-water mark and the sea at high-water, (the level of the latter is a few feet higher than the former,) to use this difference of level for sweeping off of all deposits that might have accrued.

As to the accretions we might suppose would exist in the river at the entrance of the head sluice, the study of the river's course has proved that, from its natural regimen, they are not to be feared, the accretions forming themselves on the opposite bank.

Thus, all the objections that might be raised against the opening of an artificial outlet to the Mississippi have been met. The circumstances in which we execute it must free us forever of all fear that those two great obstructors of the passes, the Mississippi and the sea, could inspire.

EXPENSES AND REVENUES OF THE CANAL.

The estimation of the cost of the canal and its revenues is subdivided in several chapters, which may be recapitulated under the following titles:

1. Value and supply of the materials.
2. Order and direction of the works.
3. Value of the works.
4. Means of execution.
5. Revenues of the canal.

1.—*Value and supply of the materials.*

The necessary materials are wood, granite, iron, cast iron, brick, lime, sand, pozzolana, shells, and fuel.

Examining, according to the rules of engineering, the resources presented by the locality, we must be surprised to find so many assembled on this spot. Excepting granite and iron, we find all the other materials on the spot and in a very limited space.

WOOD.—It is well known that the coasts of the Mississippi are one of the greatest markets for pine and cypress lumber. For more than half a century France and England have been receiving cargoes of lumber shipped from Ship Island and Pensacola. Now these two points are only distant, one sixty miles and the other one hundred and twenty miles from the canal. All the pine and cypress needed will, therefore, reach us by a direct line of navigation.

The pine logs for the piles will come at \$5 per thousand feet, delivered; the same sold as worked timber will not cost over \$10 per thousand feet; two-inch pine boards will be worth \$11.

The cypress timber will come at \$25; the cross-ties for the railroad will cost 75 cents apiece.

Oak timber brought from St. Louis, by the way of the river, may be calculated at \$35.

IRON AND CASTINGS.—Iron will only be used for smith's work, and to strengthen joints. It is an important matter in our calculations. It may be valued at 7 cents per

pound, and nails at 4 cents—all delivered. The cast iron will be used principally for the railroad, and will cost \$35 per thousand pounds.

GRANITE.—The granite will be shipped from Boston, bored to order; it will cost \$1.25 per cubic foot.

BRICKS.—No better earth for the manufacture of bricks can be found than that coming from the excavations of the canal itself. They will be made on the spot at a cost of \$7 per thousand.

LIME.—We have mentioned an island near Fort St. Philip, called "L'île à Coquilles," (Shell Island.) It is a large shell mound, furnishing all the necessary material for the manufacture of lime on a large scale. This lime can be made at a cost of 75 cents per barrel.

POZZOLANA.—The marly clay of which we have spoken will furnish the artificial pozzolana intended to change the common shell-lime into hydraulic lime. It may be valued at 50 cents.

SANDS, SHELLS, CLAY.—These materials, which are to be found on the spot, have no other value than that of the necessary labor to gather them. We will set them at 10 cents per barrel.

FUEL.—The only cost of fuel will be the labor and transportation from the banks of the river to the spot where it will be used. The inexhaustible quantity of drift-wood on the river furnishes logs, which the inhabitants on that coast have split, and sell as cord-wood to the steamboats. This wood may be valued at \$2 per cord.

Order and direction of the work.

In order that the following estimate may be understood without an examination of the detailed plan of the canal, it is proper to indicate how the works will be organized and how conducted, so as to be completed in the space of two years.

The lines of axis and outlines being marked on the ground, a gang of ditchers will dig up all the cube of earth on the bank of the river that exceeds the level of its waters. Then, two dredging-machines of 35 horse-power, and capable of excavating the depth of 12 feet, will commence at the bank of the river; they will clear all that space to be occupied by the lock and its sluices, leaving to the sides of this lump the necessary talus to prevent the caving in.

This lump once cleared, one of the machines will dig on the axis of the canal a passage of 50 feet, and, after following the passage for a distance of 200 feet, it will place itself crosswise and will begin the excavation of the channel on one of its banks. The other machine, passing by the same road, will turn in the opposite direction from the first, and will commence with the channel on its other bank. They will continue this operation indefinitely. Behind them a dredge-boat of 50 horse-power will proceed to the final excavation, to the total depth of 24 feet. During this time three pile-driving boats will begin driving the necessary piles for the formation of a dike in the river, intended to inclose in front the space of the lock. Another of these boats will drive the piles of the dike at the end of the space where the dredge-boats will have entered the channel.

When the dikes will have been completed, a draining-machine of 30 horse-power will empty completely the space and maintain it perfectly dry. Then will begin the driving of the piles for the construction of the first floor. A trellis-work will be placed on these piles and the hollows filled with béton. The trellis will be covered with a floor, on both sides of which will begin the lateral walls of the lock. A second trellis-work, with a band under each counterfort, will extend the whole length of the lock between the lateral walls, and will receive the double flooring of frame.

The mason-work of the lateral walls will be 34 feet high, 12 feet thick at the top and 24 at the base. It will be buttressed on the land-side by 22 counterforts of same thickness. The outside facings of the lateral walls will be of granite, the interior masonry of bricks laid in hydraulic cement.

While, on the river-side, the excavating of the channel and the construction of the lock will be carried on, the same operation will be performed on the sea-side.

A dredge of 50 horse-power, with capacity to excavate 24 feet, will begin the excavation from the deep-sea side, going toward Pavillon Island, on a line with the axis of the canal. When it will have excavated the space to be occupied by the mole and by the two heads of the pier, two pile-driving boats will come and drive the piles, by means of which will be constructed two dikes, one for the head of the north pier, the other for the head of the south pier with the mole attached.

When it will have reached a 12-foot depth, the 50-foot horse-power dredge will be replaced by another of 35 horse-power, which will continue the channel between the two piers of the necessary width not only for the channels, but also for the foundations of the piers; it will work this way as far as Pavillon Island. Then begins the same kind of work as at the river-head, to wit, excavating of the lump for the sea-side sluice, lengthening of a passage 50 feet, to introduce the dredge-boat in the line of the channel, the excavation of which will be done by this boat until it will have met the two other boats coming from the river-end.

Meanwhile, two dikes, one on the sea, the other in the 50-foot passage, will inclose the lump intended to receive the sluice on the sea-side.

When it will have completely inclosed, the draining-machine will drain it, and the pile-driving, trellis-frame, béton-filling, laying of the flooring and frame-work, will be constructed in the manner already explained. The masonry will be made in the same style and proportions, with granite facings, like all the other exterior facings of the constructions of the canal.

The piers and mole will have been constructed in the mean time, and these works are carried on simultaneously.

The mole is a pile of brick-work (it could be constructed of béton) forming an annular cylindrical mass, whose interior hollow is of 72 feet, and the thickness of the ring of 12 feet. It is coated outwardly with granite on all its circumference, and its upper platform is also of granite.

Finally, the piers can be undertaken independent of the other works. The first operation will be to sink in the channel comprised between their two sides, and in all the space they occupy, a flooring intended to level the bed excavated by the dredges, and to connect the two piers by a common base.

This flooring, the bottom of which is full and the upper part formed by a trellis filled with béton, will be sunk to the bottom by panels of 25 feet; once leveled by means of concrete blocks of béton having 4 feet height, 24 feet in the direction perpendicular to the axis, and 10 feet parallel thereto, will be sunk at 50 feet distance on the right and left of the axis of the canal. These blocks are hollow, and their sides are one foot thick; they may, if necessary, and for the better strengthening, be filled with earth. The face of the canal is slightly inclined. The two upper layers will only have 22 feet, offering a decrease of 2 feet on the sea-side; this graded deduction will extend to the water-line, where the length of the blocks will only be of 18 feet. The 10 feet of pier from the water-line to the level of the lateral walls of the sluice will be constructed of bricks.

In short, it will be seen that all the different points of the works may be begun simultaneously, and there is no impediment to the forming of six or seven gangs, except the assembling of so many workmen on the same spot, the difficulty of superintending such a large number, the difficulty of supplying materials, the incumbrance caused by the arrivals, and other obstacles that will be understood by practical men. It is well understood that the order of the works may be modified according to circumstances.

We will pass now to the estimate of the cost of each part of this great enterprise.

Value of the works.

SECTION 1.—Head-sluices and locks on the river:

Dikes.....	\$2,700
Excavating and draining.....	29,917
Pile-driving, trellising, and filling with béton.....	12,324
General flooring and frame-work.....	13,810
Masonry, bricks, and granite:.....	184,170
Puddling and leveling the rubbish.....	8,700
Sluice-gates and accessories.....	8,000

\$259,621

SECTION 2.—Channel and embankments:

We must set forth here the data which have served us as a basis for the estimates at this important part of the work. After a long discussion of the analogous works performed in the ports of Toulon and Valence, on the Seine, and on the bars of the Nile, the engineers of the Suez Canal have adopted machines that not only perform the excavating, but also, by means of revolving carriers, transfer the rubbish on the bank. These machines, of 35 horse-power, working 250 days per year, can excavate 375,000 cubic yards, at an average cost of 20 cents. The 50 horse-power engines will work at the rate of 30 cents per cubic yard. The work of the opening of the channel is to be done, as stated, in prairie-land for a distance of 21,580 feet, and in lagoons for 10,500 feet, on an average depth of 2 feet. During all this passage through the lagoons it is necessary to perform, on each side of the canal, a casing made of piles and boards, rising to the height of 3 feet above high-water mark, and preventing the sea from washing off the rubbish that is to form the banquettes and levee. This work is necessary in order to allow the levee to settle and consolidate.

The digging through prairie-land will cost.....	\$300,140
Through lagoons comprising the basin.....	121,596
The wood-work in the lagoons.....	16,848
The making of the levees, both in prairies and lagoons.....	182,004

620,588

We cannot pass silently the result of the calculation of filling as compared with the excavating. We had indicated, as a basis perfectly sufficient for the solidity of the levee, a length of 600 feet; that is 22½ feet of base on each side, for a height of 10 feet; but the disposable rubbish will enable us, while leaving the slope on the canal-side, to extend the base on the outer side as far as 120 feet from the banquette, which will give a nearly horizontal talus, and relieve us of all fears of the action of the sea, even in the hurricane.

SECTION 3.—Sea-side sluice, (excavating already comprised in embankments in the preceding chapter:)

Dikes and drainage.....	\$3, 164	
Piles, trellis, and béton work.....	7, 008	
General flooring and frame-work.....	5, 153	
Masonry, bricks, and granite.....	55, 302	
Puddling and leveling the rubbish.....	2, 040	
Sluice-gates and accessories.....	4, 000	
		\$76, 667

SECTION 4.—Piers and mole:

<i>Piers.</i> —Excavating and leveling rubbish.....	\$107, 584	
Inferior flooring and concrete filling.....	151, 124	
Temporary wood-work for construction of piers.....	45, 000	
Masonry, concrete works, bricks, granite heads of 200 feet both inside and outside, say 800 feet.....	646, 197	
<i>Mole.</i> —Masonry and filling, granite facings.....	50, 188	
		1, 060, 093

SECTION 5.—Accessory works and appendages:

Temporary building for the workmen, diving-bell, pumps, and fresh-water ditch, warehouse, workshop.....	\$20, 000	
Draining-machine of 30 horse-power, placed on a boat.....	8, 000	
Six boats for driving piles, at \$1,600 each.....	9, 600	
Three dredge-boats of 35 horse-power, \$12,000 each.....	36, 000	
Two dredge-boats of 50 horse-power, \$18,000 each.....	36, 000	
Cost of tools and instruments, at 10 per cent. on first cost.....	30, 000	
Single-track railroad and accessories.....	70, 000	
Two locomotives.....	20, 000	
Sundry buildings, administrator's house, lock-tenders' houses, stores, depots, workshop for the machinery, &c.....	35, 000	
		264, 600

The capital strictly necessary, resulting from what precedes, must therefore be of.....\$2, 221, 569

But it would not be prudent, in hydraulic calculations, to place unlimited confidence in an estimate. In order to meet all omissions and unexpected casualties, it is wise to add 1-5 of the total amount, say.....444, 313

Which brings the total at.....2, 665, 882

If we look back to the topographical description of the country given by us, it will be remembered that the canal crosses a region of low lands where the sea brings her alluvions, and which she sometimes destroys during her storm. The double dike of the canal, six miles in length, will break the efforts of the sea, and annul its swiftness in that section. The result will be that the lagoons will become real basins of precipitation, the bays will become lagoons, to be filled up in their turn, and the water-limit will recede forever, letting a new continent rise.

A few years will be sufficient, even if we consider only the actual rapidity of the increase, to connect permanently and securely to the continent of the left bank of the river this archipelago, now filled and leveled. Thereafter a belt-levee, similar to that of the canal, is all that will be needed to protect this new soil from the inroads of the Gulf.

The river-levee protecting it on the other side from the overflows of the Mississippi, we will have conquered from the sea a piece of land of nearly triangular shape, having six miles for the height of the triangle and about fifteen miles at its base; that is to say, a surface of about forty-five square miles. This surface, perfectly plane, formed of argillo-siliceous alluvions, would probably be suited to all sorts of cultivation, admirably developed by the salted atmosphere, so soon as the soil would have been properly reclaimed from its saline conditions by periodical overflows of fresh water, regulated by means of sluices constructed in the levee of the river.

R. MONTAUD.

2.—*Report of Board of Engineers upon Captain Howell's project for a ship-canal connecting the Mississippi River with the Gulf of Mexico.*

The Board of Engineers constituted by Special Orders No. 83, dated Headquarters Corps of Engineers, Washington, D. C. June 30, 1873, to consider and report upon the plan submitted by Capt. C. W. Howell, Corps of Engineers, for a ship-canal to connect the Mississippi River with the Gulf of Mexico, in the navigable waters thereof, made in compliance with a resolution of the House of Representatives, passed March 14, 1871, have the honor to submit this report.

The resolution referred to is as follows, viz :

Resolved, That the Secretary of War be, and is hereby, requested to cause an examination and survey, with plans and estimates of cost, to be made by an officer of engineers, for a ship-canal to connect the Mississippi River with the Gulf of Mexico, or the navigable waters thereof, of suitable location and dimensions for military, naval, and commercial purposes, and that he report upon the feasibility of the same to the House of Representatives.

In compliance with the foregoing order, the Board met in the city of New York on the 25th day of last July, and held a number of meetings during that month, and subsequently thereto, as shown by the minutes of proceedings transmitted herewith.

At these several meetings there were examined and discussed not only Captain Howell's project for the Fort St. Philip ship-canal, as set forth in considerable detail in his report of February 14, 1873, and the accompanying charts and plans, but descriptions of and reports upon similar works successfully executed by European engineers.

It being deemed expedient, before giving a formal expression to their opinions, to visit and examine the site of the proposed canal, as well as to obtain the views of local engineers upon the subject under consideration, the Board adjourned to meet in New Orleans.

The Board accordingly re-assembled in that city on the 24th day of last November, and on the 25th proceeded down the Mississippi River, viewed the proposed location of the canal, and visited Forts Jackson and St. Philip, both heavy structures, resting upon an alluvial formation in all respects similar to that through and upon which the canal would have to be constructed.

The Southwest Pass was also visited, and the working of the dredge-boat at Pass à l'Ouvre witnessed.

The opinions of distinguished local engineers were subsequently solicited, and those submitted in writing are attached to this report.

The views of prominent citizens of New Orleans interested in the commercial welfare of the Mississippi Valley were also obtained. They are fairly set forth in an article published in the New Orleans Daily Times, hereunto appended.

The conclusions formed by the Board may be briefly stated as follows, viz :

1. From the facts and data presented in official reports and otherwise, from the experience gained on works of the same character, and the many improvements made in the practice of hydraulic engineering within the last twenty-five years, but, more particularly and pertinently, from the character of the borings made by Captain Howell upon the Fort St. Philip peninsula, across which the proposed canal is to run, the Board is of the opinion that no extraordinary engineering difficulties in the construction and maintenance of the canal need be apprehended. But it is suggested, in order to avoid beds and pockets of quicksand known to exist at some points in this locality, that the precise line of the canal should not be decided upon until a more

thorough examination of the substrata has been made by borings. It is not improbable that such an examination may indicate the expediency, and perhaps the necessity, not only of adopting a curve, or a series of curves, in preference to a straight line for the axis of the canal, but also of selecting other points of termini than those recommended by Captain Howell.

Indeed, one member of the Board is in favor of locating the Gulf terminus to the northward, and consequently under the lee of Sable Point, and of securing the requisite depth of water into Isle au Breton Pass by dredging. This would naturally carry the river terminus nearer to Fort St. Philip, and perhaps within suitable distance from that work to satisfy the requirements of a good defense without the erection of special works for that purpose. The question of affording adequate military protection to the outer end of the canal forcibly suggests the head of Isle au Breton Pass, north of Sable Point, as the proper point of outlet, for the reason that suitable defensive works can be established there at less cost than at any other point. But all these questions are deemed essentially subordinate. They must, of necessity, yield to the paramount consideration of adopting that locality for the canal which shall best secure the requisite stability for the sides and bottom of the prism and the foundations of the locks.

2. With regard to the plan submitted by the engineer in charge, he has stated that it was prepared while he was pressed with other important duties, and that, under the circumstances, it was not possible to perfect all details of the project, or to make the numerous borings which are considered a necessary preliminary to a precise location of the routes of the canal throughout its entire length. The estimate submitted can therefore only be regarded as an approximation to the probable cost of the work.

3. The Board approve the *débouché* of the canal into the Gulf waters of Isle au Breton Pass, upon the ground that the advantages possessed by these waters of ample and permanent depth, and good and capacious anchorage-grounds, are not only adequate to the objects in view, but are greatly superior to those which obtain in any other locality. A comparison of old charts with those that are more recent, both verified by Captain Howell's survey, shows quite conclusively that the depth of water in this pass, as well as upon the bar at its opening into the Gulf, is quite permanent; and the Board coincide with Captain Howell's views, that existing circumstances promise a continuance of deep water in this pass.

4. The Board also approve the location of the inner end of the canal upon the straight portoin of the Mississippi River below Fort St. Philip, at such distance from that work as the final examination and borings shall indicate as most suitable, due weight being given to the question of providing adequate military protection for the work from existing fortifications, or otherwise, as may be found most advantageous.

[For a description of the canal, in order to understand the modifications recommended, reference may be made to Captain Howell's report and the accompanying plans, herewith returned.]

5. Captain Howell's project for the construction of the lift-lock contemplates a coffer-dam surrounding the entire lock. The Board entertain doubts of the practicability of this method of construction at a reasonable cost, owing to the nature of the soil and the engineering difficulties consequent thereon.

In view of this circumstance, and upon a suggestion made by the senior officer of the Board, it is believed the apprehended difficulties may be avoided by replacing the side walls of the lift-lock chamber

with gentle slopes of earth, and constructing the upper and lower lock-gates with their foundations and side walls separate from each other. With these changes the foundations of the ends of the lock can be laid by any one of the several processes well known to engineers. The bottom and sides of the lock-chamber should be revetted as far as necessary.

6. The following modifications of the proposed demensions of the canal are recommended :

Length of lock-chamber increased to 500 feet.

Width of lock at the gates reduced to 60 to 65 feet.

Depth over sill, at extreme low water in the Gulf of Mexico, reduced to 25 feet.

Depth of trunk of canal, at extreme low water in Gulf, (not changed,) 27 feet.

Width of canal at bottom, (not changed,) 200 feet.

Sides of canal to slope about 1 upon 4.

A suitable arrangement of sluices must be made to meet these proposed changes.

The foundation and construction of the guard-lock may be the same as for one of the gates of the lift-lock.

7. The jetties, extending the canal into the deep waters of Isle au Breton Pass, will doubtless require more material than the plan submitted by Captain Howell contemplates; but inasmuch as the length of these jetties and their cubic contents depend, to no inconsiderable extent, upon the positions selected for them, no very accurate estimate of their cost can be made until the final location is determined upon.

8. It is evident from the foregoing that the necessary and unavoidable absence of sufficient data to determine the best location for the line of the canal across the peninsula, including its termini, and particularly its *débouché* by jetties into Isle au Breton Pass, renders it impossible to make a close estimate of its cost.

A new estimate, resulting in part from a revision of that made by Captain Howell, has been rendered specially necessary in view of the modifications of plan recommended by the Board. It is believed to be ample to cover the cost of constructing a canal of the dimensions given above, located within the limits designated. The estimate amounts to \$10,273,000.

The subject of the improvement of the passes at the mouth of the Mississippi will be separately presented.

Respectfully submitted.

New York, January 9, 1874.

JOHN NEWTON,
Lieut. Col. of Engineers, Bvt. Maj. Gen., U. S. A.

Q. A. GILLMORE,
Major of Engineers, Bvt. Maj. Gen., U. S. A.

G. K. WARREN,
Major of Engineers, Bvt. Maj. Gen., U. S. A.

WM. P. CRAIGHILL,
Major of Engineers, Bvt. Lieut. Col., U. S. A.

G. WEITZEL,
Major of Engineers, Bvt. Maj. Gen., U. S. A.

U. W. HOWELL,
Capt. of Engineers, Bvt. Maj., U. S. A.

Not fully concurring, my views will be presented in a separate report.

J. G. BARNARD,
Colonel of Engineers, Bvt. Maj. Gen. U. S. A.

3.—*Minority Report of Colonel J. G. Barnard, Corps of Engineers.*

NEW YORK, January 20, 1874.

GENERAL : Having dissented from the views of the majority of the Board of Engineers convened by Special Order No. 83, June 30, 1873, to consider and report upon the plan submitted by Capt. C. W. Howell, Corps of Engineers, for a ship-canal to connect the Mississippi River with the Gulf of Mexico, I state at the outset, that, in making separate reports upon the particular "plan" submitted, and upon the alternative of the "improvement of the passes," my object will be to prove—

1st. That *assuming* that a canal is to be made, the plan now submitted suffices only to show that a more protracted and more comprehensive study is required to fix the location and determine the *general* details of construction, and to make an estimate which can rightly be considered *approximate*.

2d. That before resorting to an artificial work of the difficult and costly character of a "ship-canal," a more attentive consideration of the superior advantages of the natural mouths, and of the fair probability of utilizing them, is needed.

Furthermore, I add, that neither difficulties nor costs are to be weighed against the demand for an adequate navigable outlet to the Mississippi River, whether that outlet be a canal or otherwise; but the "whether" here becomes, as I think I shall show, the symbol of a question not yet solved in favor of the canal.

The first proposer of a ship-canal appears to have been Mr. Benjamin Buisson, who, in 1832, suggested that a canal "six and a half miles long, commencing on the left bank of the river, a few miles below Fort St. Philip, and entering the sea about four miles south of Breton Island, would afford an easy and safe access to the river to vessels drawing 20 feet." Subsequently, Lieut. B. Poole, a graduate of the Military Academy, serving as topographical engineer, surveyed (or, more accurately speaking, reconnoitered) this route, and reports (1837) that a canal here "offers a fairer prospect of opening the Mississippi to ships of the largest class than any other plan that has been spoken of."

But it remained for the late Maj. W. H. Chase, of the Corps of Engineers, to give the canal project a defined form by projecting in an official report dated February 9, 1837, what may be (though without drawings) properly styled a *plan* for "a ship-canal to connect the Mississippi River with the Gulf of Mexico." This plan is best exhibited by an extract from his report. He says :

The obstacles presented to an easy entrance of the Mississippi by vessels drawing 12 feet of water are productive of great injury to the commerce of New Orleans, and require to be promptly removed, or, *failing to be done*, the construction of a ship-canal on the plan indicated by Major Buisson should be resorted to.

By reference to chart, the line of the proposed canal is exhibited, commencing at a point about two and a half miles below Fort Jackson, and extending seven miles to the shores of the Gulf, and thence, by a jetty 1,760 yards, to 30 feet water. It is proposed to carry into effect this plan of a ship-canal—

I. By a construction of a guard-lock at the junction of the canal with the river. The object is to prevent the flowing of the river into the canal.

II. The excavation of the trunk of the canal, 100 feet wide at top, 30 feet wide at bottom, and 30 feet deep. The object of such large dimensions is at once to provide not only for the entrance of the largest ships engaged in commerce, but also of ships of war of the largest class. The advantages offering for both classes of vessels are obvious, and need no comment.

III The construction of the jetties or breakwaters of large dimensions, having for their base 100 feet, with a depth varying from 5 to 30 feet, and 20 feet wide at top, and raised to the level of high water.

The practicability of this plan depends solely on the question whether a lock of the dimensions required for the admission of the largest-sized vessels can be constructed on the banks of the Mississippi. I think the question may be easily answered in the affirmative, for we can refer to the practicability of excavating almost to any depth in the mud of the Mississippi Delta as exhibited at the several works constructed by the United States, and by individual enterprise. At Fort Jackson, on the Mississippi River, the foundations were excavated to the depth of 12 feet, and were kept free from water by means of a small engine attached to pumps of considerable power.

The operations at Fort Jackson came frequently under my observation, and I am left in no doubt as to the perfect practicability of excavating to the depth of 30 feet, and also of the practicability of establishing a solid foundation by piling for the support of the walls of masonry necessary for the construction of a lock.

Taking for granted, therefore, that a lock can be constructed, we have only to consider the means of excavating the trunk of the canal and the construction of a short break-water. The marsh lying between the river and the Gulf, through which the line of the canal is located, is intersected by several bayous, all of shallow depth of water. Commencing at the river, it is proposed to excavate to a depth of 6 feet, affording sufficient water for the dredging-machine, which will thereafter be employed in the excavations, the canal being excavated to a depth of 6 feet through its extent.

The estimate was for a lock 200 feet long, 50 feet wide, and 30 draught, of masonry, founded on 1,000 piles, a canal trunk 36,960 feet long, 30 feet wide at bottom, and 100 feet at top, and 30 feet deep, and two jetties, each one mile long, 1,000 feet apart, of dimensions already mentioned. A guard-lock at the sea-end does not seem to have been provided for. Major Chase's estimate for workmanship was \$8,619,299, increased to \$10,000,000, to cover superintendence contingencies.

Twenty years later, R. Montaignu, civil engineer, elaborated a plan, with considerable detail, for a canal on this identical location, with a masonry lift-lock 400 by 80, with 24 feet draught at low water, founded by means of coffer-dam on piles and grillage, a canal trunk six miles long, of identical dimensions, with "piers and moles" of peculiar construction, all of which he estimated to cost \$2,665,882.

At the suggestion of Major Chase, the line of the projected canal was embraced by Captain Talcott in his great survey of 1838. "It resulted," says the latter, "in showing a fine ship-channel leading up to where he proposed it should debouch, and the perforation of the ground to a depth of 40 feet indicated a firm bottom of sand mixed with mud, tenacious of water, and altogether such as would be considered favorable for excavating, and on which there would be no difficulty in securing a foundation for locks or structures of any kind."

This canal project was reviewed by the late Chief of Topographical Engineers, Col. J. J. Abert, in his annual report, December, 1839. After some remarks on the "difficulty of making the excavation and keeping it free in this soft soil," he states that the execution of the locks "would constitute no insurmountable difficulty if this bottom" (*i. e.*, the "firm bottom of sand and mud" found by Captain Talcott) "was adequate to sustain the locks."

These are the only points he makes concerning the engineering difficulties. But he goes on to say that the plan "would require a break-water to protect the shipping in the bay between Sable Island and Isle au Breton from eastern weather;" and again, that the plan "is subject to a very weighty objection, independent of considerations in reference to the construction, which is, that it would be exposed to the efforts of an enemy, and would involve the Government in enormous expense for its protection. This consideration would, in my (his) judgment, justify the Government in its rejection, and would turn all its views back to the previously exposed methods of improving some one of the passes of the river." (Colonel Abert's report, 1839.)

The location of the canal project now submitted to the Board is, to

all intents and purposes, identically that of Major Chase. Yet these two considerations, made so prominent by the authority I have quoted, have not received any notice whatever in the project before us. The only reference to it in the report of the majority of the Board is found in the following :

Indeed, one member of the Board is in favor of locating the Gulf terminus to the northward, and consequently under the lee of Sable Point, and of securing the requisite depth of water into Isle au Breton Pass by dredging. This would naturally carry the river terminus nearer to Fort St. Philip, and perhaps within suitable distance of that work to satisfy the requirements of a good defense, without the erection of special works for that purpose. The question of affording adequate military protection to the outer end of the canal forcibly suggests the head of Isle au Breton Pass, north of Sable Point, as the proper point of outlet, for the reason that suitable defensive works can be established there at less cost than at any other point. But all these questions are deemed essentially subordinate. They must of necessity yield to the paramount consideration of adopting that locality for the canal which shall best secure the requisite stability for the sides and bottom of the prism and the foundations of the locks, and after approving "the debouch into the Gulf waters of Isle au Breton Pass," &c., "the Board also approve the location of the inner end of the canal upon the straight portion of the Mississippi River, below Fort St. Philip, at such distance from that work as the final examination and borings shall indicate as most suitable, due weight being given to the question of providing adequate military protection for the work from existing fortifications or otherwise, as may be found most advantageous."

These paragraphs either suggest important changes of location, or they do not. From anything experience or borings into the soil has revealed, I do not consider as "paramount," in determining that location, the matters so characterized. There would be grave "difficulties," indeed, in obtaining "requisite stability for the sides and bottom of the prism and the foundations of the locks," if, as stated, matters so important as the accessibility of the canal entrance in "eastern weather," the protection of the canal-mouth, and of shipping in the roadstead against the violence of waves, and the protection of the canal-works against the maritime enemy during war, all absolutely essential and unprovided for in the project, are "essentially subordinate" to overcoming such difficulties, or to facility of dealing with them.

When it is borne in mind that the identical location of four different engineers (Captain Howell included) was governed by the "paramount consideration," (*and a very sound one by itself,*) of the *shortest distance from the river to deep-sea water*, it is scarcely comprehensible that other considerations, important enough to be weighed with *this*, become "subordinate" to difficulties of the ground. If so, the bare practicability even of the present location is rendered doubtful.

Neither observation of, and familiarity with, engineering works in Louisiana, nor the borings made by Captain Howell, suggest to me that any *material* variation in its location will be suggested by further scrutiny of the substrata by boring. My knowledge of the soil, indeed, prompts me to affirm that, so far as the "foundation of the locks" is concerned, (I do not allude, of course, to abrasion by the river,) the bearing-power of the soil is not likely to be found better or worse in one place than another. Captain Talcott found at forty feet a "firm bottom of sand mixed with mud,"* (*clay, probably,*) and the borings made by Captain Howell, after passing through various mixtures or strata of "blue clay" and "sand," exhibit generally, at about 40 feet, a stratum of indefinite depth of blue clay, with little and sometimes no sand. This stratum possesses, however, in all probability, no greater "bearing"

* I think Captain Talcott meant to say that *throughout* his forty feet of perforation he found sand mixed with mud, (or clay,) which he regarded as "firm bottom."

qualities than any of the others. Pure blue clay was found at Fort Livingston, (underlying nearly pure and incompressible sand,) at depths of from twenty to twenty-five feet. Few works in Louisiana have settled more than Fort Livingston, and there are good reasons for believing that the yielding occurred in the clay. Major Turnbull found at the site of the New Orleans custom-house, after a few feet (three or four) of light surface-matter, "stiff blue clay" slightly mixed with very fine sand, extending to depth of boring, (27 feet,) and yet that custom-house, the walls of which rest on grillages 15 feet wide, has settled nearly 2 feet. Forts Jackson and St. Philip rest on higher strata than this 40-foot stratum. Their settlement has been great, but not so great as Fort Livingston.

The strata, therefore, whether superficial or deep, are (so far as we know) all equally yielding. The mobility of the "fine sand," where it exists, as it sometimes does, in strata almost destitute of clay, may, indeed, enhance the difficulties of *making* the canal-trunk, and of *getting through them* to reach the lock-foundation, but it is not likely that any *considerable* change of location should result.

The engineering difficulties, therefore, great as they may be, have no claim to being "paramount" in the location of this canal; they are likely to have but trifling influence upon it, and are wholly subordinate to the considerations of *accessibility*—protection of its harbor *against the sea*—protection of its works *against the enemy*. The late Colonel Abert has officially affirmed that the canal, as located in the project before us, was not only *unprotected* in both these relations, but that it would demand works of such expense as to justify the Government in rejecting it, and in turning its attention to the improvement of the passes.

I do not affirm *this*; I merely say that the plan which does not treat these matters at all is not a sufficiently complete study of the project.

The first formal suggestion of a very radical change of location of the canal came from one of the professional gentlemen whom the Board consulted in New Orleans—an engineer whose professional life has been identified with the military defenses of the delta of the Mississippi River, and with the great engineering questions which the control and navigation of its waters perennially raise. (See letter of General G. T. Beauregard.) "Its location," he says, "on the river should be under the protection of the guns of Forts St. Philip and Jackson, due regard being had to the permanency of the river-bank." In a draught of a report I prepared in New Orleans, and communicated to the members of the Board, I suggested "whether a location from St. Philip to somewhere near Deep Water Point, and the dredging of a small harbor connecting with Breton Bay, (in 10 feet water,) and under the shelter of Sable Island, might not be better than bringing the canal direct into the bay, where now proposed. Such a harbor would, while tolerably sheltered, be much more easily defended against a maritime enemy."

The member of the Board "in favor of locating the Gulf terminus northward, and under the lee of Sable Point, * * * which would naturally carry the river terminus nearer to Fort St. Philip, and perhaps within suitable distance to satisfy the requirements of a good defense, *without the erection of special works for that purpose*," is understood to be one of the signers of the majority report.

The suggestions "or opinions" above cited all involve *radical change of location*. They come, therefore, from three different sources, two of which are members of the Board, and the third entitled to great consideration, for reasons already given. But I go farther in *suggestion*. A canal starting a few hundred yards below Fort St. Philip, and taking

a direction due north, (nearly,) would strike the Gulf waters at two miles distance, and the 6-foot curve at two miles and three-quarters; thence, on a line directly north to Hog Island, three miles distant, the water attains depths of 10 to 12 feet. A *dredged* harbor of the magnitude of that of the North Sea Canal (*i. e.* the dredged portion, say about two-thirds of a million superficial yards, or 136 acres) would not be an undertaking of unreasonable magnitude. It would be perfectly sheltered from storm-waves, while a dredged channel in water varying from 12 to 25 feet depth, of about five miles length, would constitute the communication to the deep waters of Breton Island Bay. The experience of dredged channels of approach to Baltimore, 24 feet deep, (ten miles, of which five miles is wholly dredged, the rest partially,) and of Atchafalaya Bay, (twelve miles long, to about 11 feet depth,) prove the efficiency of such channels. Instead of six miles of canal, there would be but two. Instead of two jetties of a mile length each, of which the cost is so formidable an item, there would be but the bulkheads (of masonry, riprap, or otherwise) from the shore-line to edge of the dredged harbor. The canal, for its whole length, would be "under the protection of the guns of Forts St. Philip and Jackson."

The anchorage of Breton Island Bay would still be as available as now. The defense of that anchorage and of the dredged channel approach suggests the desirableness of a work on Sable Point, but ~~this~~ defense is quite another matter from that of the canal itself, though rendered essential by its existence.

It is not necessary for me to *affirm* that the location and arrangement above suggested are better than those of Major Howell, Major Chase, and others. I have only to refer to the grave objections to the latter, enumerated by the late chief of Topographical Engineers, to set forth substantial reasons for my position that "a more protracted and comprehensive study is required to fix the location."

In turning now from the matter of *location* to that of plans of construction, I do not know how I can discharge the duty "to consider and report upon the plan submitted" to the board without saying that it is not one upon which it would be proper to undertake the execution of the work, nor one in which the great problems of the canal-construction are adequately solved. The majority of the board entertains doubts of the practicability (at a reasonable cost) of the method of a coffer-dam surrounding the entire lock, "owing to the nature of the soil and the engineering difficulties consequent thereon." But even if the engineering difficulties be overcome, the foundation proposed is quite inadequate. A grillage covering a surface of 112 by 550 feet, (about,) and only 6 feet thick, would be perfectly impotent to distribute pressure or to prevent distortion and cracking.*

Furthermore, I am of opinion that no thickness, within practicable limits, of grillage *alone*, will suffice to keep such a lock free from distortion and injurious settlement. This opinion is founded upon the compressible

* Simply as a confirmation, (for I did not first base my opinion on an individual instance, which had passed out of my mind,) I quote the following note, taken fourteen years ago at the Helder, (Holland:) "The new dry-dock is 350 feet long by 90 feet, (interior dimensions.) The site was excavated, the water pumped out, (the soil as deep as I could see it, which was about to the level of the bottom of the dock-floor, was mixed strata of sand and clay,) then a grillage of timbers three yards thick. The structure had been completed up to two-thirds, perhaps, of its full height. The weight of the side-walls had caused a wide longitudinal crack through the middle, the whole length of the dock, perhaps an inch or two wide. They had cut out the old lining and bottom arch, and were rebuilding it. The brick masonry was well laid, the bricks different, and the mortar not as hard as our cement mortars."

character of the clay substratum, (as already explained,) which invariably yields to superimposed weight, even if very slight. Mere settlement is not necessarily destructive of masonry structures in general, but the working of large lock-gates demands not only the most perfect freedom from distortion, but the most perfect level. As a simple means of escaping the difficulties of a deep construction so extensive, I recommended the isolated construction of the masonry gate-chambers. But *for these*, the maximum stability, only to be attained by the important auxiliary of piling, is *indispensable*.* Piling can be done without encountering the engineering difficulties of the coffer-dam process, and the masonry can be built, and lock-gates hung, whether by the pneumatic or some other method more simple and less costly. The lock dimensions (of the plan) have been modified by the majority in their report, and judiciously, I think.

The jetty construction of the plan is described by the engineer as "one of a *substantial* though *temporary* character, and must be superseded by one of *béton*, based on the foundation this one will afford."

Even if economy of time justify a "temporary" construction, the one designed would, I think, prove inadequate, and the enormous expenditure upon the so rapidly perishing timber-work, \$1,000,000, could not be regarded as judicious. Of course, there is no basis afforded for estimating the cost of the *permanent* jetties with which the work must be provided.

By reference to the project of Major Chase, it will be seen that *he* places his jetties (of a massiveness fully adequate) 1,000 feet apart, dredging the whole space between them. This arrangement provides for something like a *harbor*; and although the objection of eastern exposure is so strongly urged by Colonel Abert, the feature cited furnishes a palliative not found in the present plan.

Breton Island Bay is exactly opened to the prevailing storm-winds of the Gulf; and should *this* location be adopted, I think there can be no doubt of the necessity of creating, by the arrangement of these jetties, (starting from points on shore 1,000 or 1,200 yards distant, and converging toward the outlet,) a small artificial harbor, as at the entrance to the North Sea Canal.

Thus far, experience in Louisiana offers no example of the cutting of a canal to a depth of 25 feet, unless it be, indeed, the occasional river "cut-offs," which excavate to much greater depth. That the "prism" can be made and maintained I do not doubt, but I *do* doubt whether that result, including the protection of the sides,† formation of embankments, roadways, &c., will be attained for the total arising from an estimate of fifty cents for each cubic yard, within the defined limits of the excavated section. I doubt, however, the necessity of a bottom-width so great as 200 feet. The North Sea Canal, three times the length, has but 90 feet bottom-width. This dimension is one readily increased if experience shows the necessity.

In conclusion, I would say that while I do not doubt the entire "practicability" of the canal-construction, I think that the phraseology used in the report of the majority, that "no extraordinary engineering difficulties need be apprehended," rather underrates the real difficulties

* The plan of Major Chase—and nothing which has succeeded this plan, so boldly and so sharply defined, has been any advance—contemplated piling; so did that of his follower and (probably) imitator, Montaignu. The locks in the Y of the North Sea Canal, resting on strata of similar character, are piled.

† Sailing-vessels will, of course, be towed through the canal. That expense should not be imposed upon steam-vessels, which, of large dimensions and draught, are superseding sailers for ocean navigation.

to be anticipated. The sinking of the extensive masonry masses to a depth of more than 40 feet below the contiguous river-surface is something which has no actual precedent in Louisiana, and demands the most careful study before undertaking, and will task the skill of the engineer in execution.

The climate itself, in conjunction with the marshy soil through which the work is laid, is no *ordinary* difficulty, unless, indeed, the work be suspended for four or five months of the year. The assembling of large bodies of men on that site and under that sun, the turning up of marsh soil, impregnated with vegetable matter, cannot fail to generate their incidental diseases, and cause mortality which may hamper the progress, while the fatal epidemic of the country, unaided by such helps, would be likely to cause protracted interruptions of the work.

I do not wish to exaggerate in the slightest degree the difficulties and costs of the work, nor to deny that, if the navigation and commerce of the Mississippi cannot otherwise be adequately provided for, it can be made and should be made.

But if the execution is not to be entered upon regardless of cost and blindly as to ultimate requirements, the location must first be fixed by a wider range of considerations and study, and the plans (depending, of course, upon the location *thus fixed*) carefully matured after experimental examination of the site by careful comparison of available methods of overcoming the difficulties the character of the site reveals; and, moreover, *all that the canal project carries with it as indispensable accessories* must be planned in relation to it and enter into the estimates. Fortifications are among these indispensable accessories; so will be also some breakwater auxiliary or artificial harbor; so will certainly be the *cost of maintenance*.

Referring to the experience of other canals with locks, (the Erie may be cited,) it would not be safe to estimate this maintenance at less per annum than 2 per cent. upon the total cost for this canal.*

I have thus endeavored to prove that the plan submitted to the board suffices "only to show that a more protracted and more comprehensive study is required to fix the location and determine the *general details* of construction, and to make an estimate which can rightly be considered *approximate*."

I shall, in another report, maintain that, "before resorting to an artificial work of the difficult and costly character of a ship-canal, a more attentive consideration of the superior advantages of the natural mouths, and of the fair probability of utilizing them, is needed."

Respectfully submitted.

J. G. BARNARD,

Colonel of Engineers and Brevet Major-General.

Brig. Gen. A. A. HUMPHREYS,

Chief of Engineers, U. S. A.

ARMY BUILDING,
New York, January 28, 1874.

GENERAL: I herewith forward two sketches,† which I desire to have attached to, and made a part of, my report on the "plan submitted by Capt. C. W. Howell, Corps of Engineers, for a ship-canal," &c.

*This estimate is made with full consideration of the fact that there are no embankments, no leakage, and no "puddling" in the proposed canal; the maintenance, &c., of fortifications not included.

† For sketches see original.

No. 1 is intended to illustrate the quotations from the report (1839) of the late Col. J. J. Abert, which urges the necessity of shelter to the entrance during "eastern weather."

No. 2 is intended for reference in reading what is said concerning the question of location and of defense by *existing fortifications*.

Very respectfully, your most obedient,

J. G. BARNARD,

Colonel of Engineers and Brevet Major-General.

Brig. Gen. A. A. HUMPHREYS,

Chief of Engineers, U. S. A.

4.—*Report of Board of Engineers on the improvement of the passes as an alternative to or in connection with the canal.*

NEW YORK, January 13, 1874.

The Board of Engineers convened by Special Orders No. 83, headquarters Corps of Engineers, Washington, D. C., dated June 30, 1873, to report upon the project of a ship-canal to connect the Mississippi River with the deep waters of the Gulf of Mexico, having had the matters referred to them extended by the following instructions, viz :

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 3, 1873.

SIR: In reply to your letter of the 24th ultimo, I am directed by the Chief of Engineers to say that it is allowable and desirable to have the views of the Board of Engineers on the question as to the expediency of improving the navigable outlet of the Mississippi, by the Fort St. Philip Canal, as an alternative to, or a simultaneous measure, perhaps, with, the improvement of the passes.

The report of Captain Talcott, of January 30, is in the hands of the copyist, and will be furnished you as soon as possible.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Major of Engineers.

Col. J. G. BARNARD,
Corps of Engineers.

have the honor to submit this report :

The improvement of the passes has usually been discussed in reference to the application to them of the jetty-system, or of dredging, in conjunction with each other, or separately, and the board propose to confine their attention to these methods.

The depth of water over the bar to serve for commercial, naval, and military purposes, it is assumed, should be the same as that selected for the draught over the miter-sill of the proposed ship-canal, viz, 25 feet at extreme low water of the Gulf. The pass to be improved is assumed to be Pass à Loutre; this having been selected by several engineers advocating the improvement of the mouths of the Mississippi as the best adapted to the application of the jetty-system.

In order to advance the low-water twenty-five-foot curve of the channel of the pass from the point where this depth ceases to obtain to the bar, it would be necessary to construct parallel jetties, of the same distance apart as the shore-lines of the pass where the required depth is excavated.

These considerations fix the length of each jetty at about 24,000 feet, and the distance apart 2,200 feet.

The top of the jetties must be held low, not higher than the banks from which they extend, because additional height, while adding to their cost, would not induce the passage of more water between them so long as the banks of the river above are at a lower level. An elevation of the jetties above the banks from which they spring would, in fact, endanger the latter in the presence of a rise overtopping them, especially at the points where the jetties and banks unite.

The debouch of Pass à Loutre by two mouths makes it necessary to close one of them, and this operation is supposed to be performed by the north jetty, constructed across the northern mouth.

An inspection of the map of the pass, to fix in the mind the necessary course of the northern jetty, will show that the present direction of the running waters will be deflected by this work, which forms a concave bend to receive them, and a considerable scour of the bank must necessarily ensue, causing the foundations of the jetty to be undermined, unless effective measures are taken to prevent such catastrophe.

The board are unable at this time to suggest any remedy except to sink the foundations deep enough to be out of reach of these influences. As to how great this depth should be to insure safety, the board have no certain means of judging, but it may be 25 feet, or even more.

The closing of the northern mouth, which, following the line of jetty, would be a work operating to deflect the present direction of the currents, and over 7,000 feet in length, is an undertaking of great delicacy, the cost of which, in a soil of the character pertaining to this locality, might prove to be excessive. Success in this operation is, however, necessary to the application of the jetty-system to the pass under consideration, and must be sought at whatever cost, in order to accomplish the desired improvement of navigation. (Note A.)

It is important to say that the advance of the jetties, step by step, will cause deep holes to form at their extremities, due to the escape of the waters as soon as released, and a consequent excavation of the loose soil, which will much increase the depth and cost of these works.

The dislodgment, by the operation of the jetties, of the immense quantities of material from the sides and bottom of the channel would bring the scouring force into contact with the interior of the banks and shoals, which consist generally of soil inferior in hardness and firmness; and it would be impossible so to fix the limits of this disturbing action that it might not often reach the jetties themselves.

The long, low banks and the shoals of the delta do not owe their existence or permanence to anything inherent in the strength and consistence of the soil composing them—for on these points all testimony agrees—but upon the action of the waves and currents, constituting an area of equilibrium, in which the particles are deposited and retained.

But as these forces are not always as to effect, but only periodically, in equilibrium, it necessarily follows that changes in the shoals and banks are constantly occurring, not enough, indeed, to interfere with the general development of the delta, which appears to advance by virtue of uniform laws, but quite sufficient to endanger and even destroy the most skillfully-designed works. (Note B.)

This consideration of the unstable and treacherous nature of the shoals and banks is necessary in order to fix the mind upon the cost and risk as well as upon the disappointment which would likely attend an attempt, upon such foundations, to construct works to coerce or control the currents of the passes.

An estimate has been prepared by Captain Howell, engineer in charge

of the jetties described in this report, supposing them to rest upon the natural bottom, without settlement, as follows :

Fascines and ballast, at \$5 per cubic yard	\$2, 545, 220 00
Riprap stone, \$7 per ton	2, 241, 097 60
Total	4, 786, 317 60

If settlement and the other probabilities enhancing the cost of this work, as already discussed, be considered, it appears entirely within limits to state that the above estimate should be doubled.

Assuming that it will take about four years to complete the jetties to the present 25-foot curve outside the bar, and estimating the least yearly advance of the bar at 250 feet, it would be proper to add to the estimate already the cost of 2,000 linear feet, equal to \$68,888.

There is, besides, the estimate for future annual extensions to keep pace with an increased advance of the bar, which by the same authority would be \$1,613 per linear foot of jetty.

The next step in order is to consider the effects of these jetties, supposed to terminate at the curve of 25 feet outside the bar, upon the depth of water in the channel and upon the bar; and it will be first supposed that the jetties, if projected too far apart, should near the bar be brought together sufficiently close to insure the desired scouring effect upon the bar.

Would this state of things, thus produced, endure for a considerable time, or for a period sufficient to fill up the deep space ahead in the Gulf to a distance equal to the present interval between the termination of the 25-foot curve in the channel and the outer crest of the bar?

The principles upon which a reply to these questions depends have been exhaustively treated in Chapter VIII of Humphreys and Abbot's Report on the Physics and Hydraulics of the Mississippi River; and there is nothing more to add, except the conclusions which follow from that report.

Let us suppose, as the first effects of the jetties, the 25-foot curve to have advanced to the original outer crest of the bar. It will be found that the position of the crest has already advanced, due to the large amount excavated from the sides and bottom of the channel, and the ordinary supply of materials which are rolled on the bottom and deposited on the outer slope; and it is not certain that there would be a full depth of 25 feet at the new crest, on account of the tendency to form the upper surface of this deposit coinciding with the angle at which the river-waters emerging from between the pier-heads would be deflected upward by the waters of the Gulf, an effect which the spread of the river-waters, after their release from the confinement of the jetties, would increase. The succeeding flood, while advancing the bar, should, upon the same principles, still further decrease the depth over its outer crest; and every advance of the bar would be followed by a similar result. Hence the jetties, in order to retain the depth gained, should keep 'pace in their extension with the progress of the bar. At high-water of river, the deposits are made exteriorly; at low-water, interiorly. During the changes from high to low water, the deposits are made between these two, or on what is ordinarily considered the bar.

A condition of things likely to occur periodically, whereby a medium stage of the river, without high floods, might be maintained, would cause unusual deposits upon the bar; and hence an additional reason for the conclusion, apparent already from the first portion of this discussion upon the bar, that in order to secure, at all times, a depth of

25 feet, provision should be made in the arrangement of the jetties to excavate to a depth greater than that. (Note C.)

As a case in point, Major Stokes, royal engineers, in his paper upon the improvement of the Sulina mouth of the Danube, states that it 1863, owing to the absence of floods in the river, a bank formed within the pier-heads almost in the position of the old bar, greatly contracting the channel, though not actually barring it.

If it is not already apparent that the deep space ahead will not of itself prevent the restoration of a shoal depth to the bar after once deepening it, reference may be had to the fact that a shoal bar, for over one hundred years, has been advancing at Pass à Loutré, over a deep space ahead, and at an average rate of about 300 feet a year.

In proportion as the cross-section of discharge on the outer crest of the deposit widens, its progress into the Gulf will become slower, and the depth of water upon it will constantly decrease.

(Humphreys and Abbot, pp. 446, 447.) On the other hand, if the cross-section be narrowed, the progress into the Gulf of the deposits will become more rapid.

This rapid extension of the pass into the Gulf would tend to increase the volumes of the shorter passes at the expense of its own, and it would eventually be necessary to resort to another pass for the continuance of the plan. (Ibid., p. 456.)

This yearly progress of the bar demands a corresponding extension of the jetties into deep water exposed to the severe storms of the Gulf, and consequently of great cost.

The difficulties at the mouth of the Mississippi, so far as concerns the improvement by jetties, resolve themselves into three sources:

1. The absence of a littoral current.
2. The yielding nature of the banks and shoals.
3. The abundance of deposits.

The first and third combine in the yearly and rapid extension of the bar, and compel the works of improvement to continue at a heavy annual cost until their entire abandonment.

The second makes their construction difficult and their maintenance improbable, unless deeply founded at a very heavy expense.

All the principal objections to the improvement of Pass à Loutré necessarily apply to the Southwest Pass.

But the board does not clearly understand why Pass à Loutré has been preferred for improvement by jetties, its exposure to the storms and storm-tides of the Gulf being much greater than that of the Southwest Pass; and it may be added that the direction of jetties at the Southwest Pass would be straight, while at the other pass they would be inclined to the direction of the current, which is objectionable.

Pass à Loutré, however, has the advantage of being directly in the track of vessels bound to and from the East. The length of both jetties at Southwest Pass, designed for the same objects as at Pass à Loutré, would amount to 54,000 linear feet. It is proper to state that these lengths were taken from a Coast Survey map, of a scale smaller than that of the map of Pass à Loutré, made by the engineer in charge for the operations of the dredging-machine, and upon which the improvement of Pass à Loutré was discussed by the board.

In the study of improvements of this character it is well to refer to instances where trial has been made, holding in view always the sound principle that the fact of work having proved successful, or having failed, at any river-mouth, by no means insures that the same kind of works will succeed or fail at any other river-mouth unless the very same conditions exist.

The board is indebted to the article (Vol. XIII, Professional Papers) of Major Stokes, R. E., British commissioner for the improvement of

the mouths of the Danube, for much of the matter in the present discussion immediately following.

From 1594 to 1682 attempts were made to improve the Vistula by extending piers seaward from its mouth. "A breach in the root of this pier, through which the river cut itself a lateral communication with the gulf 10 or 12 feet deep, suggested the idea of obtaining a permanent channel independent of the mouth."

The extension of the piers from the mouth of this new channel converted into a canal did not avail to secure the requisite draught. "The author was informed by the engineer who, in 1858, had charge of all the Prussian harbor-works, that no efforts were available to keep open a greater depth than 10 feet into the canal before the year 1840.

* * * It was not till after the breaking through of another mouth several miles to the east, in 1840, as before mentioned, that the Prussian engineers could congratulate themselves on having obtained a good entrance to the port of Dantzic. * * * The river was at once shut off from its old course * * * by a dam.

* * * The old mouth was cut off from the sea by a solid dam.

* * * By these means an excellent channel of 17 feet was obtained," (at the mouth of the canal,) "and has since been maintained by constant dredging. As already mentioned, the dredging is carried on under peculiarly favorable circumstances, as the Gulf of Dantzic is land-locked. * * *

In the Gulf of Dantzic there can hardly be said to exist a littoral current. The littoral current of the Baltic, from west to east, passes along the Helas * * * and strikes again the coast, which then immediately trends to the north. The main force of the current is then carried northward, but a portion of it sets into the Gulf of Dantzic from east to west, * * * while a second current, passing round the head of the Helas, sweeps along the shore of the gulf, and, traveling from west to east, meets the main current somewhere opposite the old mouth. No more unfavorable circumstances for the opening of the mouth of the river could be imagined. The river issuing into slack-water at the meeting of the two currents threw down its deposits at once." * * *

The two attempts, which were persevered in for more than one hundred and fifty years, to keep a channel open for sea-going vessels at the mouth of the river or of the canal, failed, and it was not until the fortuitous opening of another mouth, five miles away from the old mouth, which removed the deposits to a distance, that success was obtained.

The causes of non-success were:

1. Absence or neutralization of littoral currents.
2. Abundance of deposits.

The causes of final success were:

1. A stoppage of deposits.
2. Dredging in a sheltered gulf.

The character of the piers, which were chiefly built of riprap, as shown in the plates accompanying this article, indicates that the foundations were not of the yielding nature of the Mississippi deposits, and as there is no mention made of difficulties arising from the nature of the bed, it is assumed to have been ordinarily good.

The Board passes to another instance of improvement, cited from the same author, of the mouths of rivers in tideless seas, viz, the Sulina mouth of the Danube.

The improvement was made by the construction of parallel piers.

The north pier is a continuation of the left bank of the river. It is 4,640 feet in length, and is carried out to what was the 16-foot line before the work was even begun. *

The south pier approaches the north pier on a curve, and then runs parallel with it, terminating 600 feet short of the other pier.

The construction was of an outer line of sheet-piling, stayed by a framing of piles and timbers, the foot of the sheet-piling being protected on both sides by a large deposit or bank of stone, rising to the level of the water. At intervals there was an inner row of sheet-piling, with cross-lines to the outer row, the space or box thus formed being filled with stone, and both rows protected on their exterior by a deposit of stone.

Since the construction of piers the depth has never been less than 16 feet, and is usually 17 feet, there having been at times a good channel of 17½ feet.

The piers were finished in 1861, and in 1863, the date of the article, the experience was that the depth varied at times from 16 to 17½ feet, the latter belonging to floods of "unusual violence."

Spring floods of that year had formed a menacing bank on the continuation of the north pier and about 2,500 feet to seaward of it, but this bank was speedily broken down by the spring gales and carried away by the littoral current. In 1862 the floods threw down a similar bank, but without obstructing the navigation, and that bank was again removed by the action of storms and currents. * * * The rapidity with which they were removed seems to favor the supposition that the bar will only creep across the front of the piers when the general advance of the delta should have pushed the littoral current farther away from them, and thus have caused a double effect dangerous to the channel.

In the first place, the river current would not then be turned southward, and would throw down its deposits immediately in front of the piers; * * * and, secondly, the banks thus formed, instead of being broken down by the gales and carried southward, would be driven back on the channel, which they would choke still more.

Since this article was published, it is ascertained that the south pier has been extended as far seaward as the north, and that a depth of 20 feet has been obtained.

The board are not in possession of a paper on the same subject, by Sir Charles Hartley, the distinguished engineer who constructed these piers; but it is impossible to entertain a question as to the causes of the success of the pier system at this place.

An inspection of the map accompanying the article shows a great development of the delta form at the Kilia mouth, and the same formation to a less degree at the St. George mouth, with a consequent projection outward of the shore-line; but at the Sulina mouth no formation of the kind is distinctly traceable, and it is inferred, though the fact is not material, that the quantity of sediment emptied at this outlet is small in comparison with the others.

The construction of the piers indicates a difference in the character of the bed, as to resistance, from that of the Mississippi, it being certain that this description of work would not answer at the latter place.

The cases of the Vistula and of the Sulina mouth of the Danube manifest essential points of divergence from the circumstances attending the improvement of the Mississippi, and the results obtained in the former cases constitute no precedent for the employment of the same means at the latter place.

Upon a review of the practical difficulties which the adoption of the jetty system of improvement at the mouth of the Mississippi would entail, and a due consideration of the original cost of construction and of annual extension, entertaining doubts, moreover, of the successful issue of the attempt, the board does not consider it advisable to recommend it.

With regard to the cost of this operation, owing to the uncertain nature of the problem, made so by the peculiar risks attending it, the board find it impossible to fix any reliable limits.

The estimate in this report, made upon a hypothesis favorable to the project, indeed, but which does not exist, is useful only to convey to the mind some idea of the magnitude of the undertaking.

As an auxiliary to the improvement by jetties of the mouths, dredge-boats must be employed to remove mud-lumps.

The other means of improving the depth at the mouths, by the stirring-up process, has already been put to the test of practice.

Two boats, the *Essayons* and the *McAlester*, have operated upon Southwest Pass and upon Pass à Loutre.

These dredges can begin work upon a bar having only 11 feet of water. The former can excavate to the depth of 20 feet, the latter boat to a depth of 22 feet.

Operations at Southwest Pass between July 1, 1872, and April 1, 1873: The width of the channel made varied from 50 to 250 feet. The depth varied from 20 to 13 feet. For $39\frac{1}{2}$ days, $19\frac{1}{2}$ to 20 feet in depth; for 120 days, $17\frac{1}{2}$ to 19 feet in depth; for 90 days, 17 feet in depth; for 22 days, 13 to $16\frac{1}{2}$ feet in depth.

The smaller depths, from 13 to and including 17 feet, were due mainly to blockades and other obstructions formed by grounding vessels.

From July 1, 1872, to April 1, 1873, 53 vessels grounded at Southwest Pass, and were the cause of there being less than 18 feet in the channel after November 1. To April 1, 1873, the dredges worked 58 days. Suspension of work on account of slack current, 62 days; fogs, 21 days; waves, 16 days; repairing, 36 days. The remainder of the time is accounted for in coaling, pulling grounded-vessels out of the way, and suspension of work on Sundays.

Operations at Pass à Loutre from April 1 to June 30, 1873: Starting at $11\frac{1}{2}$ feet depth on the bar, worked 78 days. From May 27 to July 1, the depth was $17\frac{1}{2}$ feet at extreme low-water of the Gulf.

This favorable comparison of working-days at Pass à Loutre is due to several causes, viz, the small number of vessels passing through; the absence of grounding; the protection which the outer shoals afford to the bar, and the sufficiency of the currents during the period in question.

It should be noted that the stoppages were from causes beyond control, and, consequently, which could not be remedied by better boats or more of them. The grounding of boats, the stoppages, and the shoaling in consequence thereof could have been prevented in many cases by good regulations, well enforced.

The effect of the stirring-up process is to sift out the finer, leaving on the bottom the heavier, sandy particles, thus forming a surface harder than the natural one of the bar. Nevertheless, vessels pulled with powerful tugs are drawn through with a draught greater by one foot than the depth of channel. This operation would not generally succeed with long sea-going steamers.

The results so far do not warrant the board in estimating a greater depth than 18 feet at extreme low-water as capable of being maintained at the passes by means of the stirring process. This is inadequate to the requirements of the naval, military, and commercial services.

Although the stirring-up process cannot, therefore, be made a substitute for a project affording the proper depth, it should be continued until such project shall have been completed.

It is understood that one member of the board of 1852—Major Chase, (now deceased)—was in favor of the canal project, (Note D.) Another member, Major Beauregard, has expressed his opinion very emphatically in favor of a ship-canal, and doubtfully as to the jetty system. This

testimony is valuable, as springing from the matured judgment of an experienced engineer, well acquainted with the subject he discusses, and is an evidence of a prevailing conviction which points to the fact that the time has come for obtaining an outlet to the ocean of depth sufficient to meet the necessities of the great valley of the Mississippi, and that the canal offers the best and most certain means of attaining this result.

JOHN NEWTON,
Lieut. Col. of Engineers, Brevet Major-General.
 Q. A. GILLMORE,
Major of Engineers, Brevet Major-General.
 WM. P. CRAIGHILL,
Major of Engineers.
 G. WEITZEL,
Major of Engineers, Brevet Major-General.
 C. W. HOWELL,
Captain of Engineers, Brevet Major.

Not fully concurring in the above, my views will be submitted in a separate report.

J. G. BARNARD,
Colonel of Engineers and Brevet Major-General.

Dissenting from the report of the Board in but one point of opinion, I have signed the report, reserving mention. Referring to my report on the canal, also to my answer to a letter addressed me by the president of the Board, both submitted with the report of the Board, it will be observed, as the probable depth of channel to be maintained by dredging on the bars under stated conditions, I name 20 feet. This is considered by the Board an over-sanguine estimate, more especially since the past record of dredging does not show the maintenance of an 18-foot channel.

While adhering to my opinion, I must acknowledge that, so far as I know, I am the only engineer holding it.

C. W. HOWELL,
Captain of Engineers, U. S. A.

NOTE A.—The operation of closing the north mouth by a work which at the same time changes the direction of the current, appears to be doubtful of success, as well as excessive in cost; and the question arises whether it would not be better, first, to close the mouth by a dam below the position of the works, and then to construct the line of jetty. In this way the difficulties would be separately met, and the cost might be kept within limits capable of being fixed.

NOTE B.—The influences of the jetties will develop additional forces tending to change the form and equilibrium of the shoals.

NOTE C.—And hence the jetties, in order to carry into the Gulf a depth greater than 25 feet, must be of greater length, at a less distance apart, founded in deeper water, and situated farther down the slope of the banks, all of which circumstances are unfavorable, as to the cost and difficulties of construction.

NOTE D.—Major Chase had, in 1837, submitted a project and estimate for a ship-canal.

5.—*Minority Report of Col. J. G. Barnard, Corps of Engineers.*

ARMY BUILDING,
New York, January 29, 1874.

GENERAL: In a partial report January 20, confined to the discussion of the "*plan* submitted by Capt. C. W. Howell, Corps of Engineers, for a ship-canal to connect the Mississippi River with the Gulf of Mexico," I stated that in another report "I shall maintain that before resorting to an artificial work of the difficult and costly character of a ship-canal, a more attentive consideration of the superior advantages of the natural mouths, and of the fair probability of utilizing them, is needed."

This investigation is called for by your express desire "to have the views of the Board of Engineers on the question as to the expediency of improving the navigable waters of the Mississippi by the Fort St. Philip Canal as an alternative to or a simultaneous measure, perhaps, with the improvement of the passes," and as I could not concur in the views of the majority of the Board on these subjects, this separate exposition of my own is rendered necessary.

There are but two methods of improving the passes which call for notice:

1st. *Dredging*, in which may be included all the varieties of that process, such as "stirring up," "harrowing," &c.

2d. Jetties at one or more of the mouths, by which to concentrate the current upon the bar and thereby cause its removal.

Of the first process only has any actual knowledge by experiment been attained, and some notice of the history of this experience will be in place.

Under the first appropriation for the improvement of the mouths of the Mississippi, in 1837, "dredging" with "buckets" was recommended by a Board of Engineers, and a powerful machine constructed and set to work. But its cost and the outlay upon the survey consumed the appropriation before the method had been tested; and no other appropriation was made till 1852. In that year an appropriation of \$75,000 was made for opening "a ship-channel of sufficient capacity to accommodate the wants of commerce;" and it was further provided that the said money should be applied by "contract," and that the contract should be "limited to the amount appropriated."

In order to decide how to apply this appropriation under the stipulations of the law, the Secretary of War (Mr. Conrad) convened a mixed naval and engineer Board, (its members were the late Commodore W. K. Latimer, U. S. N., the late Maj. W. H. Chase, United States Engineers, Maj. G. T. Beauregard, United States Engineers, and the undersigned,) and submitted to it certain queries. All these officers had served long on the Gulf coast, the three latter, as engineers, having had much experience with construction and engineering problems connected with the Lower Mississippi. Major Chase had, indeed, been one of the very first engineers to propose, in 1837, a ship-canal, and the first to define his views by a *project*, which has been noticed in my first report.

No other plan suggested itself to that board by which the \$75,000 could be applied with some hope of obtaining any important result than that of "stirring up" the bottom; and upon their recommendation a contract was entered into with the Tow-boat Association, by which a channel through the bar at Southwest Pass 18 feet deep and 300 feet wide was to be made. The execution of this contract was the very

first successful application of any artificial means to deepening the channels over the bars, and it *demonstrated* the efficiency of dredging by *that method*. Inasmuch, however, as the Board could not foresee with certainty this success, they, in recommending another appropriation of \$150,000, also recommended, *should in the mean time the dredging processes prove failures*, to apply it to the construction of jetties of the Southwest Pass, remarking that the "project of jetties is based upon the simple fact that, by confining the waters which now escape uselessly in lateral directions to a narrow channel, the depth of this narrow channel must be increased—in other words, the existing bar must be cut away." As auxiliary to the jetty system, the Board recommended the closing of certain minor outlets in order to increase the volume flowing through Pass à Loutre. The board concludes by saying that, should methods of operating upon the natural outlets—the mouths—"all fail," there is yet a plan to fall back upon, viz, A SHIP-CANAL. They express their conviction of its *practicability*, and recommend "that the engineer charged with these works should be directed to employ such time as he can spare to an investigation of the subject, having reference to the possibility of a future recurrence to this project."

No further appropriation was made till 1856, and as a consequence the 18-foot channel completed in 1853 was speedily filled. In the year mentioned an appropriation of \$330,000 was made for the improvement of the passes. A Board of Engineers recommended that the proposals of the Tow-boat Association should be accepted for keeping open the Southwest Pass, by the already successfully-tested method of stirring up the mud, and that a proposal of Messrs. Craig and Rightor for keeping open Pass à Loutre by means of jetties, and closure of minor passes, be accepted.

By direction of the Secretary of War (Mr. Davis) their plans and proposals for *both* passes were accepted, and the contractors began at the Southwest Pass, by building on the east side a jetty about a mile long, *composed of a single row of pile planks, strengthened at intervals by pile*. Portions of this jetty were carried away by storms, and the contractors abandoned the plan, and were permitted to resort to the "stirring-up" method, by which they opened, in 1858, two channels 18 feet deep, which, as long as the process was continued, preserved this depth. (Physics and Hydraulics of the Mississippi, p. 455.)

Such, substantially, was the experience up to the interruption of all operations by the civil war.

In 1867 an appropriation of \$75,000 was made, and a contract entered into, for "stirring up," which, however, was not executed.

The engineer in charge (the late Maj. M. D. McAlester) then designed a boat (the *Essayons*) especially adapted to the stirring-up process, by agency of propeller-blades extending below the keel, and, with the balance of the appropriation just named and that of 1867, (\$200,000,) the vessel was built, and the system, as improved by Major Howell, by the addition of the deflector, which more effectually directs the stirred-up material into the upper currents, has been since in operation with eminent success.

"The results have been such" (in the language of Major Howell) "as to warrant yet more liberal action. With the success attending the work of dredging the bar at Southwest Pass during the past two years, the commerce seeking the port of New Orleans has grown rapidly.

"Lines of steamships before in the trade have built new vessels for it; other old lines have been attracted to it; new lines have their vessels in course of construction, and sailing-vessels in greater number than

before have been engaged in it, all taking fuller cargoes, making quicker trips, with greater profit to owners and reduced expense to shippers. The cotton trade of the upper cotton region, for a time partially diverted from this route, is returning, and a grain trade has been inaugurated which promises to attain large proportions.

"While the great benefit already derived from dredging is acknowledged, there remains in the minds of commercial men doubt as to its continuance to meet the growing demand for deeper-draught vessels.

"There is yet more serious doubt regarding the continuance of suitable action on the part of Congress, in making appropriations seasonably and in amount to prevent interruption of the work. Distrust in the continued effectiveness of dredging can only be overcome by long-continued success, and simply retards commercial progress.

"Distrust of the continued good will of Congress is of more serious import. The work in progress is dependent for its continuance on an annual appropriation. It is of a character requiring continued work. Suspension for a few weeks or months will permit the natural agencies, always at work, to obliterate all evidences of previous improvement, and return the channels across the bar at the river-outlets to their normal and obstructed condition.

"Such occurrence would be disastrous in the extreme. It would ruin the commerce now promising such good results, ruin the merchants engaged in it, and destroy confidence in plans for its revival at any future time. Yet such occurrence is not improbable, as evidenced by the past record of the work.

"Legislative economy enters too largely into the spirit of American politics to permit of men engaged in legitimate business staking their wealth, when it will depend on the turn legislation may take. What is required to inspire confidence in the future of the commerce of the Mississippi River is a permanent outlet—not one of uncertain tenure. Dredging, from its dependence on legislation, does not offer such."

It is further stated by the engineer in charge, in an official letter to the president of the board, that, *provided* that enough money be furnished to keep the two dredge-boats now in service employed all the year round, except when under repair, and further *provided* the engineer have full control over the use of the channel, with authority to assess fines in cases where injury may result from ignorant or malicious handling of vessels in the channel, to be collected in the United States courts, THEN a channel may be made and maintained at one of the passes *with 20 feet depth at extreme low-tide*; and the cost for the same would be \$150,000 per annum for "running expenses," and a new dredge-boat, costing \$250,000 every five years, or an average cost of \$200,000 per annum. (See letter of Major Howell, appended.)

If these official expressions of the engineer in charge be not deemed strong enough, reference may be made to the following passages from his annual report of September 18, 1873:

That natural causes effecting a blockade of the mouth of the Mississippi have been overcome by the system of dredging adopted, *so far as regards obtaining a 20-foot channel across the bar at the Southwest Pass*, is evidenced by my reports.

Even the popular prejudice against dredging has been overcome, and the people of New Orleans, most interested, to-day acknowledge the good done.

In consequence, with means at my command *abundantly able to overcome all natural obstacles to the formation and maintenance of a good channel at the mouth of the Mississippi River*, I have not been able to accomplish the latter, and this fact, with those who do not appreciate the other facts, discredits my work, the system of dredging, and my ability as an engineer, &c.

It has already been stated that the very first attempt at "stirring up the bottom" successfully created a channel on the Southwest Bar 300 feet wide and 18 feet deep, for the sum of \$75,000. Subsequently, (1858,) Messrs. Craig & Rightor having failed in their efforts at jetty-construction, succeeded, by means of "stirring up the bottom with harrows and scrapers, dredging with buckets in some places," &c., "in making *two* channels 18 feet deep, and as long as the process of stirring up the bottom was continued by them, the channels preserved the requisite depth." (Phys. and Hyds. of the Miss., p. 455.) Subsequently (1859) the Department took the work in hand, still using the plan of stirring up the bottom by "dragging harrows and scrapers" over it. "The plan proved to be successful, and a depth of 18 feet was maintained upon the bar for the period of one year, at a cost of \$60,000."

Thus we see that the very earliest attempt, by improvised methods, at *scratching* the surface of the bar with harrows, &c., produced, for \$75,000, an 18-foot channel; that the process was repeated in 1858 with the same success, and *two* 18-foot channels obtained; and finally, the thing was *again* done under the immediate direction of the Department, and for the small sum of \$60,000 a depth of 18 feet was maintained for a period of one year.

In face of these *facts*; in the face of the positive, formal, and official statement of the engineer in charge "that, *so far as regards obtaining a 20-foot channel*, the natural obstacles have been overcome, (reiterated under different forms,) and in face of the fact that since the proved success of stirring up by scraping with harrows, &c., for \$60,000 a year, machinery expressly designed to this end has been invented and improved upon, under the eye of engineer officers, to be operated at an expense of *two hundred thousand dollars* per annum, the majority* of the Board advise you that "the results, so far, do not warrant the board in estimating a greater depth than 18 feet, at extreme low water, as capable of being maintained at the passes by means of the stirring-up process;" and, furthermore, that "this is inadequate to the requirements of the naval, military, and commercial services."

By reference to the best authority I have proved the adequacy of dredging operations on the bar by well-tested means; but I think there is yet room for improvement, and especially in diminishing cost. The utilization of the power of the current may perhaps be yet further effected,† while the attainment of 20 feet depth on the bar has by no means been established to be the maximum. As to *that* depth, however, we have the strongest assurances.

With 20 feet at extreme low-tide, vessels drawing 22½ feet could, owing to the softness of the bar, frequent the port of New Orleans, and

* The engineer, Captain Howell, of course, could not concur in our opinion in so direct conflict with his official statements. In his paragraph of dissent he avows himself to be "the only engineer, so far as he knows," who believes his own assertion that the "natural obstacles to obtaining a 20-foot channel across the bar of the Southwest Pass have been overcome," or who is so "sanguine" as to believe that with the two powerful and especially-designed dredge-boats, and \$150,000 per annum, he can accomplish more than *has been accomplished by others* without such machinery, and for \$60,000. But he certainly *knew my opinion*; not a singular one, I imagine, or one for which it would be of importance to cite names.

† A simple design was made by one of the members of the board of 1852, (Major Beauregard,) and again brought to the attention of the general board. Its trial was urgently recommended by all the members of the first-named board, and by other competent judges.

‡ Average high-tide is about 1½ feet above "extreme" low-tide. Vessels drawing a foot more than depth on bar *can* (though with some difficulty) pass. On the miter-sills of a lock a clearance of 1 foot is stated to me by one of our naval constructors to be necessary for vessels of heavy tonnage and large draught.

for mere commercial purposes probably 20 feet draught would be adequate. A draught of 23 feet will include 85 per cent. of the shipping of the world; and with a draught of but 18 feet vessels (steamers) can be built of 5,000 tons, carrying 70,000 bushels of corn, or about 11,000 bales of cotton.* It is clear, then, that, for commercial purposes, a depth of 20 feet on the bars of the passes will suffice to furnish a navigable outlet, and relieve the commerce of the valley from enhanced charges arising from insufficient tonnage in the transports.

The engineer has, in language already quoted, very forcibly described the impetus given to commerce through the passes by the successful dredging operations of the last two or three years; but the benefit, he says, is qualified partly by the doubt whether the process will meet the "future demands for vessels of deeper draught," but still more by *doubt as to the uninterrupted annual appropriations by Congress*; and hence the *real* obstacle to that confidence which will justify business men in investing their money in lines of steamships of magnitude such as will bring the cereals and cotton of the valley through this route, appears to be *uncertainty as to the annual appropriations by Congress*.

The remedy for this is clearly pointed out in the "Physics and Hydraulics of the Mississippi," in the very last paragraph of that work, (p. 456,) viz, "that a *permanent fund* be provided, untrammelled by restriction as to the mode of the expenditure, from which a sufficient sum annually can be relied upon for the continuous prosecution of the work," &c.

Congress has power, I presume, to provide such fund, or to make appropriations applicable for future years. But if absolute *freedom of use* be not claimed for the canal, if tolls enough merely for *maintenance* be imposed, then with equal propriety an amount no greater (for no greater is needed) may be raised from vessels passing the deepened bars.

An objection to a reliance upon the dredging process is urged that it could not be maintained during a period of war with a powerful maritime enemy. This objection implies a state of *continuous blockade* at the mouth of the river, and a protracted war. Protracted wars between powerful nations are no longer probable; they are ceasing to be *possible*; while the supposition of continuous blockade to one of our greatest seaports would be repelled, and indeed would be more destructive of the commercial use of the river-mouths than the usual bar obstruction.

The objection is not therefore in the same category with the demand for the defense of the works of an artificial canal, and it is not an overruling one. Still an improvement of one or more of the natural mouths by which a sufficient depth should be afforded without the continuous use of machinery, and which would not be subject to the objection just cited, would be desirable.

In turning to the subject of jetties, I do not know how I can better define at the outset my position in relation to them than by quoting from the draught of a report which has been submitted to the board, and which has already passed through your hands:

I can only reason on *probabilities* deduced from study of the river and the lights of experience; and so long as to establish the negative there has been, I need not say, no *trial* of the system, but not even a survey accompanied with a careful study and experiments, directed expressly to develop the cost and character of the work needed, I feel that I am justified in recommending it as *probably* furnishing the most speedy attainment of a deep-water channel, and one which will have some features of permanence.

* See prospectus of Atlantic, Great Western and Southern Steamship Company. The proposed vessels draw but 18 feet.

In a passage already quoted from the report of the board of 1852, the *rationale* of the jetty system is explained. I further cite from the "Physics and Hydraulics of the Mississippi" the following:

The development of the laws which govern the formation of the bars has removed all uncertainty as to the principles which should guide an attempt to deepen the channel over them. The erosive or excavating power of the current must be increased relatively to the depositing action. This may be done either by increasing the absolute velocity of the current over the bar or by artificially aiding its action. To the first class of works belong jetties and the closure of lateral outlets; to the latter stirring up the bottom by suitable machinery, blasting, dragging the material seaward, and dredging by buckets. These plans are all correct in theory, and the selection from them should be governed by economical considerations.

Such is the theory, and no engineer has yet expressed a doubt as to the fact that concentration of the waters of one of the passes by jetties carried out to deep water *would excavate the required deep channel*. The difficulty and the cost of construction, the alleged necessity of costly annual extension, furnish the arguments why this method should not be resorted to. While the general laws which govern the formation of bars at river-mouths are universal, there are peculiarities in the formation due to the *natural* differences of character of the rivers and of the sea-shore where the mouth is situated. If the shore be itself sand or gravel, and not rock, a bar *always* forms, whether the river brings down sediment or not. The latter material *cannot*, therefore, be regarded as in any sense the *cause* of the bar, though when it exists it is found to be the material of which the bar is composed. The most intractable bars are usually found to be of the former class; and yet, with few exceptions, every harbor on our northern lakes constituted by a river or creek mouth has been improved by the construction of parallel jetties. That those jetties need sometimes to be *prolonged* is no denial of their efficacy.

In the thirteenth volume of the professional papers of the Royal Engineers, four different instances of the application of jetties are described: two, the Danube and the Oder, (the first a sediment, the second a non-sediment, bearing river,) successfully; another, the Vistula, (sediment-bearing,) unsuccessfully; and the fourth, the Rhone, of which it is stated: "They cannot be said to have failed, (for they were never fairly tried,) though their failure *there* would constitute no argument against their employment elsewhere."

Concerning the Vistula it is stated, "*no more unfavorable circumstances for the opening of the river could be imagined*" than those that existed at the old mouth, where, for one hundred and fifty years, jetties (*always used*, however) failed to produce an adequate permanent depth. In 1840 the river burst through a narrow tongue of land and formed a new mouth, five miles from the old one, to which "piers" (jetties) were *immediately applied*, by the effect of which, aided by dredging, a depth of 17 feet is obtained. Jetties were not, therefore, total failures, after all.

At the mouth of the Adour, below Bayonne, (not cited in the volume referred to,) piers were carried out one and a half miles long in nearly parallel lines and with a narrow channel. The bar here was "shingle," (i. e., gravel or pebbles,) and the operation is described (Minutes Institution Civil Engineers, 1861-'62) as "a total failure."*

The conspicuous instance of the *success* of jetties is that at the Danube

* Nevertheless the depth is said to have been increased; but inside, at a distance of half a mile from the original bar, an interior bar was formed, due probably to the *seawaves'* action on the shingle.

mouth. Here, as in the case of our own great river, a great sediment-bearing * river discharges into a (nearly) tideless sea :

The base of the triangle which constitutes the delta forms upon the general outline of the coasts of the Black Sea a strongly-pronounced salient, which is connected with the primitive shore-line by curved contours. A complete analogy is thus found between the form of this delta and those of the other great rivers, the Nile, Ganges, and Mississippi. (*Annales des Pontes et Chaussées*, Nov., 1872.)

Nevertheless, compared with the Mississippi delta, there are very strongly-marked *differences* :

There were at the Danube delta two natural actions going on. Opposite to each of the mouths of the river there was an accumulation ; between the mouths there was an erosion of the shore. If the river had not been there it was natural to suppose that the whole of the shore would have been eaten away uniformly ; and therefore the amount of solid matter brought down by the river was not to be measured by the apparent width of the extension opposite to the mouths, but by the width of that extension added to the width of the recession in the parts between the mouths. This tendency to erosion from causes independent of the river was another circumstance conducive to success. (Minutes of Proceedings of Institution of Civil Engineers, vol. xxxvi, p. 231.)

And, again, the formation (at the Sulina mouth, at least) exhibits firmness and (sometimes) even hardness. The village of Sulina, at the very mouth, is, in part at least, of stone buildings, on the natural soil. The bar sometimes, and especially during times of floods of the upland rivers, (the *first* effect of high floods having been with the unimproved bar to deepen it, the *second* to reform it further out, and of harder materials,†) being incrustated with hard sand, which yields with difficulty to the plowing action of a vessel's keel, and the lateral shoals on which the jetties were laid being sufficiently firm to support the "riprap" construction without materially yielding.

Another point of *alleged* difference, very much insisted upon by many, is the *littoral current* off the Danube mouths. Colonel Stokes, R. E., (British commissioner,) states :

Its existence was ascertained before the works were carried out, the author having instituted a series of observations with floats to test the amount of the current, the result of which proved that there was a decided current across the mouth of the river, which extended as low as 4 feet below the surface in a depth of 10 feet. The depth on the bar at that time was 8 or 9 feet. It was also shown that during calms, northerly and north westerly winds, there was a considerable littoral current from north to south, and during southerly and south westerly winds, a surface current from south to north ; but it was so feeble as to indicate that the force of the wind had but just overcome that of the current from north to south. In strong westerly winds there was a counter-current setting in about 5 feet or 6 feet below the surface ; but this was not observed during the northerly winds, which so generally prevailed at the mouth. The Kilia branch, fifteen miles north of the Sulina, discharged two-thirds of the water of the Danube into the Black Sea, the whole of which set past the mouth of the Sulina.

Seamen found a very constant current of from one-half knot to one knot per hour, setting from the north to the south along the coast of the delta. Colonel Stokes therefore thought it established that there was a littoral current generally from north to south across the Sulina mouth. (Minutes of Proceedings of Institution of Civil Engineers, vol. xxxvi, p. 247.)

To the undersigned Sir Charles Hartley stated that the current averaged about half a mile, confirming also the fact of its occasional fluctuation.

Again it is to be observed that while each particular pass (and even each small "bayou") of the Mississippi delta thrusts out, in its own particular finger-like promontory, the Sulina mouth is not thus thrust out, but is on the general line of the shore.

* The ratio of solid to fluid in the Danube waters is by volume $\frac{1}{173}$; nearly the same as for the Mississippi.

† The usual depth was about 9 feet, varying, however, from $7\frac{1}{2}$ to $11\frac{1}{2}$ feet.

The Danube divides at about fifty miles from the coast into the Kilia and Toulcha branches, of which the former conveys two-thirds (about) of the entire discharge. The latter and more southern branch again divides into the St. George's and Sulina arms; the latter running eastward nearly. The St. George conveys nearly one-third, leaving to the Sulina but two-twenty-sevenths. The mouths of the Kilia and St. George are about forty miles separated, the Sulina mouth nearly midway between them, the trend of the coast-line being north and south. Finally it may be said, the discharges of the St. George and the Southwest Pass of the Mississippi have the same ratios, one-third of the total discharge, and the Sulina the same ratio as the South Pass, ($7\frac{1}{2}$ to 8 per cent.) Hence, the total discharge of the Mississippi being more than three times that of the Danube, the Southwest Pass discharges three times as much as the St. George, and the South Pass three times as much as the Sulina. The current-velocities are, if anything, somewhat greater in the Danube than in the Mississippi, the inclination of surface in the Sulina 3 inches per mile during floods, and about 1 inch per mile at low-water.

The sea-depths at three miles from land are 16 fathoms off the St. George, and only 10 fathoms off the Kilia and Sulina.

On the other hand, at 1,000 feet outside the bar of the Southwest Pass, the Gulf is about 22 feet deep; at 4,700 feet, 100 feet deep; at 43,000 feet (eight miles) 300 feet deep; and eleven miles, 900 feet deep, 150 fathoms. (Physics and Hydraulics of the Mississippi, p. 444.)

The Kilia, though the greater arm, was deemed ineligible in consequence of its subdivision into numerous small delta-arms of its own. To the St. George, possessing a good navigable channel with 16 feet of water, (while that of the Sulina, with but 13 feet, was very bad,) was given the preference.

When the engineer presented his plans to the European commission it had three other designs before it "from eminent technical authorities" who had visited the ground:

In one respect alone all were agreed, and that was in recommending that whichever mouth were chosen, the system of improvement should be that of guiding the river-waters across the bar, by means of piers projected from the most advanced dry angles of the mouth; or, in other words, that of concentrating the strength of the river-current, on the bottom of the proposed improved seaward channel, by an artificial prolongation of the river-banks into deep water.—(Minutes of Proceedings of Institution of Civil Engineers, vol. xxi, p. 284.)

The English, French, Prussian, and Sardinian governments then referred the whole subject to the decision of two military and two civil engineers. These gentlemen, in an elaborate report, unanimously condemned the jetty system, and "recommended the choice of the St. George branch with a sea-entry and gates," (in other words, a "ship-canal") "independent of the mouth; a project diametrically opposed in principle to the system of improvement previously proposed by all the naval and engineering authorities, who had visited the several mouths of the Danube, and had studied their peculiarities on the spot." (*Ibid.*)

The final result of these complications, and of the impatience of the merchants for some immediate relief, was that the commission, under advice of its engineer, "resolved to improve the channel across the bar of the Sulina branch, by means of guiding-piers of a temporary character, but carried out in the lines which the author had designed for permanent works."

It is not in place to go into particulars concerning the progress of a work protracted through many years through inadequacy of funds

The piers, as designed, were 5,850 and 4,310 feet long, starting at points on shore 2,500 feet apart, and converging to parallelism about 600 feet apart.

The results are thus stated by Sir Charles Hartley, (Minutes of Proceedings of Institution of Civil Engineers, vol. xxxvi, pp. 208, 209:)

1 That when the European commission of the Danube began its labors, in 1856, the entrance to the Sulina branch was a wild, open seaboard stream, strewn with wrecks, the hulls and masts of which, sticking out of the submerged sand-banks, gave to mariners the only guide where the deepest channel was to be found.

2. That the depth of the channel varied from 7 feet to 1½ feet, and was rarely more than 9 feet.

3. That the site now occupied by wide quays, raised high above flood-level and more than two miles in length, was then entirely covered with water when the sea rose a few inches above the ordinary level, and that, even in a perfect calm, the banks of the river near the mouth were only indicated by clusters of wretched hovels built on piles, and by narrow patches of sand skirted by tall weeds, the only vegetable-product of the vast swamps beyond.

4. That in the summer of 1857, three months of constant dredging and raking on the bar produced no appreciable effect.

5. That on the completion of the provisional piers, in 1861, the depth on the bar increased to 17 feet, and Sulina, instead of being the worst harbor, at once took the highest rank among the best commercial harbors in the Black Sea.

Finally, by the prolongation of the south pier, the consolidation and rendering *permanent* the work, at an expense equal to the first cost of the temporary structure, and by other improvements, an effective depth of 20 feet was attained in 1872, and since maintained.*

So far from a rapid advance or protrusion of the bar having ensued, "the piers have hitherto had the effect of diminishing by more than one-half the old rate of the advance of the delta at the Sulina mouth as represented by the 24-foot line and 30-foot line of soundings; of encouraging the growth of the sand-banks directly under the shelter of the south pier; and of causing a rapid erosion of the sea-bottom northward of the north pier along its whole length, an action which has naturally extended itself to the line of shore, thus necessitating, as has already been observed, a prolongation of 694 feet from the shore-end of the pier. The causes of these phenomena may be briefly explained as follows: The slower advance of the delta, as limited by the tails of the 24-foot bank and of the 30-foot bank, is due to the circumstance that the great bulk of the silt-bearing waters of the river, on issuing, as at present, at once into deep water beyond the pier-heads, is, as a rule, carried far to the southeast by the littoral current, instead of flowing into the sea, as formerly, with a feeble and constantly decreasing current, by numerous shallow channels, which were always changing in direction and extent. * * * The remarkable erosion to the north of the piers is probably chiefly due to the rebound of the sea against the north pier during heavy northerly and northeasterly gales."

Simultaneously with this it is observed that opposite the Ochakoff mouth of the Kilia, the 6-foot line of soundings has advanced 6,000 and the 30-foot line 5,000 feet, since 1856, or at the rate of 333 feet per annum.

I have thus given, with the utmost detail that I could venture to use in such a report, the circumstances of the somewhat famous Sulina-

* Since the prolongation of the south pier had prevented the formation of the bank between the two pier-heads, there had been no symptoms of deterioration of the channel. * * * * Vessels had passed out during the spring of the current year drawing 20 feet 3 inches. (Discussion of a paper by Sir Charles Hartley, May 13, 1873, Minutes of Proceedings Institution C. E., vol. xxxvi.)

Danube improvement, to show how and under what circumstances a river-arm, discharging only one-third of the water that is discharged by the South Pass of the Mississippi River, has been made to afford a good navigable entrance, with an "effective depth" of twenty feet, while the bar "advance," instead of being accelerated, has been retarded. Those who examine the problem *without the light of these results*, would be slow to believe that the local circumstances were decidedly favorable; that they were *more* favorable than those offered by the Mississippi. The *hardness* of the shoals favors, indeed, construction, but indicates a more thorough sifting by the sea-waves of the sedimentary matter rolled along the bottom, while such a bar on a shallow coast directly exposed to storm-waves is usually an unpromising subject for improvement. The littoral current, at best feeble, scarcely, if at all, exceeds that which is imputed ("Physics and Hydraulics of the Mississippi," p. 449) to the Gulf waters of the Mississippi bars.*

On the other hand, the very rapid deepening of the Gulf immediately off the bars, and the favorable exposure of their external slopes to the action of the sea-waves and currents generated by easterly storm-winds, are circumstances decidedly favorable. Surely there is ground here, especially when we weigh the inestimable benefit of an open RIVER MOUTH, to pause at least long enough for a mature study and investigation, not merely on paper, but by surveys and measurement at the localities, to collect the special data which bear upon the application of the project to them, instead of, by a hasty pre-judgment founded on inadequate knowledge, deciding that there is *no* remedy to the evils *but* the gigantic and costly alternative of a ship-canal.

It is proper, however, to allude to the more prominent objections. One of them is based upon the following, from "Physics and Hydraulics of the Mississippi:"

If the excavating power and depositing action of the Southwest Pass had been equal when the yearly advance of the bar was 700 feet instead of 338 feet, the least depth upon it would have been 21 feet. This increase of excavating power may be obtained by constructing two converging jetties, beginning where the depth of 22 feet is found, and extended to that depth outside the crest of the bar, which would give them a length of about 2.5 miles.

The depth of 21 feet thus obtained must be maintained by the annual extension of the jetties 700 feet into the Gulf.

This dictum is founded upon a theory of bar-formation, which is doubtless true, and yet does not contain the whole truth; for were the Gulf waters fresh and of same specific gravity as those of the river, there would still be a bar; moreover, the stretching of any theory of so complicated phenomena to *numerical* results is generally putting upon it more than it will bear. Some confirmation may be attributed to the fact that Captain Howell's surveys show an advance of 500 feet to the southwest bar, while under the operations of his dredge-boats. Dredging by this method, or its equivalent, has been in operation during a considerable fraction of the high-water periods since 1853, and it would be desirable to know whether a decided acceleration of advance has resulted; at any rate we need a wider induction than Captain Howell's survey yet furnishes. Without pausing on this point, or discussing the applicability of the theory to an equal deepening by jetties, I prefer to dismiss the Southwest Pass, as one to which an experimental application

* Vessels making for the Southwest Pass from the capes of Florida are, after east and southeast gales, carried to the westward of their reckoning. Hence, in part, the construction of a costly light-house on Timbalier Island, sixty miles west of the Southwest Pass. Major Damrell, light-house engineer, confirms the existence of a western current off Mobile Bay entrance.

of jetties would be unadvisable. So I have always regarded it. To obtain 25 feet depth of water, it would not be wise to enter into contest with the forces of nature developed in the discharge of a stream larger than the whole Danube. The excessive *length* of pier-construction simply to reach the bar to be deepened, should be decisive as to the matter of selection.

The objection just treated, together with others arising from the peculiarities of Pass à Loutre, and the expense of construction, are dwelt upon at length in the report of the majority of this board. Simply to show that the cost need not *à priori* be set down as out of reasonable bounds, I selected the Pass à Loutre, and, in a preliminary draught of a report made at New Orleans, sketched out an application of jetties. I stated that from the point in the pass where the depth of 25 feet ceases to obtain, to the outer crest of the bar, is about two and a half miles. This has reference to the pass *below* the division of the North Pass. Not from any supposed lack of water, but because there was a shoal at the division, and, in short, to make a full estimate for what others might *allege* to be necessary, I commenced above the North Pass, included the stopping of that pass, and made jetties four miles long instead of two and a half. I placed my jetties in the natural banks or upon the shoals. The estimate of the majority is founded, apparently, upon taking a normal distance apart of 2,200 feet, preserving *perfect parallelism*, (by which the jetties are throughout their *entire length*, over four and a half miles, *laid in deep water*.) The closing of the North Pass is pronounced not only a "necessary" but a "delicate" and withal costly operation, "which must be sought at whatever cost in order to meet the desired improvement."

The *exclusion* rather than the addition of this water would be desirable,* but as this is not the place for discussion of projects, I simply content myself with the bare statement, and remark further that even if the water-way is to be restricted to 2,200 feet for four and one-half miles, the selection of the best ground for the jetties at distances apart considerably greater than 2,200 feet is not debarred. Short auxiliary jetties of slight construction, perpendicular to the main ones, will contract the water-way. Such parallelism is not, however, suggested in the paragraph I have quoted from Physics and Hydraulics of the Mississippi, nor practiced at the Sulina.

For reasons above given, the hypothetical application of the majority of the board is erroneous in principle and elaborately unfavorable. An average section (fascines and ballast) of 32 square yards (say 12 feet broad on top and 12 feet deep) is attributed the whole length of four and a half miles of each jetty, and on the bottom and slopes of this *total of nine miles* of "fascines and ballast" is laid an average of twenty tons of riprap per running yard, (increasing by 50 per cent. the average section just described,) a total of riprap (320,000 tons) more than one-third of that in the Delaware breakwater and ice-breaker. Two-thirds of the construction (admitting the lengths to be necessary) could be laid on the natural banks or on ground marked "bare at low water," and be little more than levees, and generally the location would not be exposed to the violent sea-action which requires the voluminous re-enforcement by riprap applied to sea-jetties of the character that seems to be adopted.

* There is a very similar case presented at the St. George mouth of the Danube. The Kedrilles channel of the St. George branch, carrying two-thirds of the water, by a division very similar to that at Pass à Loutre, reaches its bar at a distance of two miles. In contemplating the improvement of this arm Sir Charles Hartley considered it would have been objectionable rather than desirable to close the other outlet.

(See Professional Papers, Corps of Engineers, U. S. A., No. 22, pp. 60, 61.) The question submitted, however, is not so much "to recommend its trial" (of the jetty system) as to recommend its *consideration*, and that scrutiny and survey on which alone estimates can be based.

For the same reason, however, that I have from the outset regarded the Southwest Pass as ineligible, I would as a subject of initial operations dismiss from present consideration Pass à Loutre. In the discussion before the institution of civil engineers (Minutes 1861, 1862) Sir Charles Hartley said "that he did not consider it an advantage to have a large body of water discharging at the entrance. *That was the only disadvantage of the St. George as compared with the Sulina.* The more the quantity of water the greater would be the amount of deposit;" and it is a conclusion of that engineer that "it is more advisable to improve the mouth of a minor branch of a river rather than to grapple with the difficulties of a principal branch, if that minor branch offer sufficient depth and width, or nearly so, for the navigation down to the point where its waters are discharged into the sea."

If this language had been used to describe the South Pass of the Mississippi, it could scarcely have been more exactly fitted. As the shortest, it is the pass of which the natural advance is least rapid; it is nearly straight. Its average depth from the head of the passes to the head of its offshoot, Grand Bayou, is by Talcott 27 feet, by the most recent Coast Survey chart 38 feet, thence to inner edge of bar 24½ feet by Talcott, and 29 feet by Coast Survey, (1867.) Its least width is more than 500 feet. We have here, then, a pass of which the *natural capacity* is almost precisely that which is needed, and of a magnitude amenable, with comparative ease, to works of improvement. Its channel can be easily improved and regulated, the bar at the head of the passes removed, minor outlets closed, and even (if desirable) more water be directed into it. From the bar the nearest unsubmerged shore is about two miles on the east side and one mile on the west, and these distances would lie generally in very shoal water. Hence for an experimental trial this pass should be selected.

The important fact that at the Sulina-Danube mouth the progress of bar-advance has been retarded rather than accelerated,* that in the opinion of the distinguished engineer who accomplished that work, such will *generally* be the effect of jetties (when the bar due to sediment of a muddy river is in question) should, I think, cause some hesitation in adopting a theoretical view of accelerated advance; especially as the theory leaves out of consideration the counteracting effects of currents and waves. But if reference is had to the theory, the case here offered is more analogous to that presented on page 445, Physics and Hydraulics of the Mississippi, in which the mouth is supposed removed to some point where the pass has its normal section and mean depth, and the Gulf to occupy its place, (*i. e.* that no bar has yet formed.) The carrying forward of the normal section and mean depth of a pass to the deep water of the Gulf has only this difference, that the process implies the erosion and deposit beyond of the material of the *existing* bar. In the hypothetical case the *formation* of the bar is admitted to require time.

I am not called upon to make a plan or an estimate. If successful at all, (and I have endeavored to show that success is promised,) the cost will be a small fraction of that of the canal. On the other hand, the

The permanent deepening on the bar which existed at this Danube mouth appears to be a well-established fact. It is an experimental demonstration of the efficacy of longitudinal jetties for improving the bars at the sea-mouths of rivers. (*Annales des Ponts et Chaussées*, November, 1872.)

advantages of an open river-mouth are inestimable. The needs of a navigation so great as that which now exists, and which in the future of the great Mississippi Valley must be fifty-fold increased, demand it.

It is said that "the time has come" when the needs of commerce demand the canal; but I answer that the *time will come* when there will be the same cry for a navigation unimpeded by locks—AN OPEN RIVER-MOUTH—which we now hear for a canal. But in whatever aspect the question be regarded the use of the river-mouth for the next ten years is simply inevitable.

The conditions of the location and execution of a canal have received no adequate study. The plan, boldly and ably, yet so imperfectly, sketched out nearly forty years ago by one for seventeen years my commanding officer or professional associate, W. H. Chase, is yet, in its engineering features, the best plan extant; and the grave objections to *that* apply with even greater force to the present project, and demand new studies of location and an entire revision of plans of execution. It would be a rash confidence which would contemplate a realized "Fort St. Philip Ship-Canal" earlier than A. D. 1884.

In the mean time shall the routes of commerce of the great West be yet more effectually than now diverted to the Atlantic ports; or shall the public confidence be directed to the *present* adequacy of the operations upon the bars; and shall the problem, which sooner or later *must come*, of an *open river-mouth*, be solved?

Respectfully submitted.

J. G. BARNARD,

Colonel of Engineers and Bvt. Maj. Gen., President of Board.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

6.—*Minority report of Major G. K. Warren, Corps of Engineers.*

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, R. I., January 15, 1874.

GENERAL: As a member of the Board of Engineers considering the Fort St. Philip Canal project for connecting the deep waters of the Mississippi River and the Gulf of Mexico, directed by you to also consider the alternative proposition of making this connection by deepening the water over the bars in the natural outlets, I beg leave to say that on this last proposition I do not feel possessed of the data for a detailed report, nor do I see how these can be obtained but by costly experience. Any conclusions reached now must unavoidably rest upon what is, in a measure, assumed, and opposite conclusions will be reached by others using the same liberty.

My mind, however, is fixed upon the idea that the canal is the only project that will meet the commercial, naval, and military demands of the United States. Its feasibility has never been doubted by any one, and only on account of its cost have other methods been heretofore recommended. These other methods have always been regarded as experiments, and the reliance has been that, if they failed, the canal, as a final resort, was certain.

I believe the time has come when that which appears certain should be tried first.

The cost of the canal will not be great compared with the end to be gained; and there is no certainty that we will not have to come to it

after great delay and expenditure upon other methods, none of which, when abandoned, will have aided in the least toward constructing the canal.

Very respectfully,

G. K. WARREN,

Major of Engineers, Bvt. Maj. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Report of the Chief of Engineers.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., April 15, 1874.

SIR: In transmitting the reports of the Board of Engineers upon the ship-canal from the Mississippi River, near Fort St. Philip, to Isle au Breton Pass, and upon deepening the entrance to that river by constructing jetties at the mouth of one of its passes, I abstained from any discussion of the question of applying the jetty system to improving the entrance, as certain information, important in the final treatment of the subject, had not then been collected by Captain Howell. This comprised certain soundings from the bars of the Southwest and South Passes out seaward several miles, as well as other data, including a carefully-prepared plan and estimate of the cost of applying the jetty system to those two passes.

All the results of the soundings connected with the bar of the Southwest Pass have been received, and the most important of those relating to the South Pass bar, and I beg leave to present some views upon the subject which necessarily assume the form of a review of what has been advanced by others.

The important fact developed by the soundings recently made by Captain Howell relates to the depth now existing in the Gulf, just seaward of the mouths of the river. Taking the maps and profiles exhibiting the depth as it existed in 1838, and recognizing the fact that the bar of the Southwest Pass has advanced since 1838 at the rate of about 300 feet in a year, the jetty advocates have taken it for granted that the bars of the Southwest and other passes are now being extended in a part of the Gulf where the water is very deep, into which very deep water the jetties will push the obstructing part of the bar, which they erode, and also the material which forms the bar's annual growth, and will thus easily maintain the depth of 25 feet, or greater, on the bar. But during all this time, since 1838, the river-water, in addition to pushing the bars annually into the Gulf about 300 feet, has been depositing the greater part of the earthy matter it held in suspension upon the bottom of the Gulf, beginning at the outer edges of the bars, and extending seaward between five and ten miles. This is not the earthy matter forming the bar, which the river-water pushed along its bed until it reached the sea, but the earthy matter which forms the bottom of the Gulf for several miles seaward of the bars.

Upon examining the map of the recent soundings of Captain Howell we find that, at the crest of the present bar of the Southwest Pass, there was, in 1838, a depth of 125 feet. We also find that where, in 1838, at the distance of 13,000 feet seaward of the bar, there was a depth of 145 feet, there is now only a depth of 45 feet, (this point, where the depth is only 45 feet, being 3,000 feet seaward of the crest of the bar.) We find,

further, that this bar is now being extended annually into the Gulf in water not so deep as the bar was advancing in 1838. We find, also, that from the crest of the present bar to a depth of 100 feet the distance is now 8,000 feet; whereas, in 1838, from the crest of the bar to 100 feet depth the distance was 4,700 feet; and we find, further, that from this point, where there is now 100 feet depth outward, for the distance of some eight or ten miles, the deposit made on the bottom of the Gulf between 1838 and 1873 is between 60 and 70 feet thick, or at about the rate of 2 feet per year.

The mean annual amount of earthy matter in suspension carried to the Gulf by the Mississippi River would cover an area of one square mile 241 feet thick. The Southwest Pass carries to the sea 0.34 part of this, and the larger portion of this mass is deposited on an area about two and a half miles wide and ten miles long. If all were deposited on this area it would form a deposit 3.26 feet thick. We have found, by the comparison of soundings, that over much the greater portion of the area the deposit is, on an average, 2 feet thick. The other portions of the suspended matter are carried ten or twenty miles, or even greater distances, farther seaward, and also over greater widths than the mean I have used of two and a half miles.

The opinion has been expressed by some engineers, in discussing the question of the application of the jetty system to the entrance of the Mississippi River, that the earthy matter of the bar and the earthy matter held in suspension will be pushed out by the jetties so far that a littoral current, which is supposed by them to exist outside the bar, will carry this earthy matter away from the approach to the entrance.

They seem either to forget or not to know that the greater part of the earthy matter held in suspension which is brought to the crest of the bars is deposited between the crest and points from five to ten miles directly seaward of them, and in the direction of the mid-line of the pass prolonged, which direction the current of the river maintains after it passes over the crest of the bar.

If there was a littoral current of force sufficient to carry off any large quantity of this earthy matter, it would not have been deposited where it is now, and always has been, found. What has been said respecting the recent soundings of Captain Howell exhibits this fact clearly.

Further, upon examining the horizontal curves of equal depth on Captain Howell's recently-prepared map, going out as far as a depth of 350 feet, we find that, from the crest of the bar to 100 feet depth, the greatest amount of deposit is made east of the axis or mid-line of the pass prolonged; between 100 feet and 200 feet depth the greatest amount of deposit is made west of that line, and between 200 and 350 feet the greatest amount of deposit is made east of that line. Further, the investigations into the currents made under Captain Talcott's direction in 1838, for the very purpose of ascertaining whether there was a littoral current, failed to detect its existence off any of the passes, the investigations in the case of the Southwest Pass extending seven miles seaward of the bar.

The very shape of the delta is indicative of the absence of such current. Its increase in the direction of the mouths of the passes, and the existence of such areas of water as Blind Bay, Garden Island Bay, and East and West Bays, which would have been gradually filled in the course of the delta-formation by deposit if such current had existed, all point to its absence.

The investigations carried on under my direction, in 1851 and subsequently, show, with sufficient precision for any application to engineer-

ing purposes, what the nature, direction, and force of the currents of the Gulf are (as distinguished from the currents of the river-water) off the mouths of the Mississippi River. The effect of these currents upon the passes, their mouths and bar-formations, was discussed in the chapter of the report treating of that subject, and was fully considered in preparing the part entitled "Experimental theory of the formation of the bars."

These Gulf-currents are due to changes of the level of the Gulf, owing to tides and winds, and their resulting effect (together with that of the waves) upon the passes, their bars, and their sea-deposit, are all shown by the actual position of the passes and the conditions existing at their mouths; and there is no ground whatever for anticipating any modification of their action by building jetties; they will neither carry away from nor bring to the bar or the bottom of the Gulf any more earthy matter if jetties should be built than they do now, and their influence upon the jetty system is absolutely nothing.

The prominence which has recently been given to the effect of a littoral current in connection with the jetty system is derived entirely from the influence attributed to it in the case of the improvement by jetties of the Sulina branch of the Danube; and because the South Pass is the smallest of the passes of the Mississippi River, it seems to be assumed that the conditions of the Sulina will be found at the South Pass.

The Sulina branch of the Danube carries off one-fourteenth part of the volume of that river, and its mouth lies about midway between the mouths of the two main branches, the mouths of the Kilia branch being about fifteen or twenty miles north of it, and of the St. George branch being about the same distance south of it. The Kilia branch carries off two-thirds of the volume of the Danube, the St. George one-third, from which the Sulina takes its supply.

The discharge of the Danube, in flood, is about 333,000 cubic feet per second; in low water, about 111,000 cubic feet per second. The discharge of the Sulina, in high water, is about 24,000 cubic feet per second; in low water, about 8,000 cubic feet per second.

The South Pass of the Mississippi discharges, in high water, about 83,000 cubic feet per second, and in low water about 25,000 cubic feet per second, and carries to the sea ten times as much earthy matter as the Sulina branch, almost the same quantity as the Kilia branch, and nearly two-thirds as much as the whole Danube.

The small quantity of earthy matter carried to the sea by the Sulina branch, joined to the fact of the existence of a littoral current across its mouth, were the two causes which, in the judgment of Sir Charles Hartley, the engineer of the commission for the improvement of the mouths of the Danube, made the jetty system peculiarly applicable there and led to its success, the jetties causing the earthy matter in suspension to be carried out into the littoral current, which then carried a large part of it away.

This littoral current did not extend to the bottom of the sea or surface of the bar, but merely a few feet below the surface of the sea. It is stated that there is no tide in the Black Sea, the variations of the level of its surface being due to winds. At the mouth of the Danube the northeast winds, being not only the prevalent wind but nearly incessant, causes a littoral southerly current along the west shore, the mouths of the Danube being, in a northerly extension of the Black Sea, about one hundred and twenty-five miles wide. The discharge of the Kilia branch, on its way to the Bosphorus, after it has dropped its earthy

matter, passes across the mouth of the Sulina branch and strengthens the littoral current derived from the wind.

Let us examine a little more closely into the facts of the Sulina improvement. I find, by a comparison of the Russian map of 1829, and the English map of 1857, of and off the Sulina mouth of the Danube, (see Minutes of Proceedings Institute Civil Engineers, vol. xxi, 1861-'62,) that the old (1829) inside 12-foot curve of the bar did not progress seaward during that time, but receded 250 feet, and worked to the northward that extent or more.

The old outside 12-foot curve (of 1829) in some places did not move out, in others moved eastward 200 or 300 feet, and in others twice as much. Its mean movement is 350 feet in 28 years, or 13 feet per year. The outside 15-foot curve on the old channel-line, for the full width of the mouth of the river, did not move out appreciably. South of the natural channel the 15-foot curve moved out 800 feet in the twenty-eight years; north of the natural channel it moved out 500 feet in the twenty-eight years, the mean advance of the curve in the twenty-eight years being something less than 600 feet, or about 22 feet per year. The mean outward movement of the 30-foot curve, however, is 3,000 feet in twenty-eight years, or about 110 feet per year. It is evident, then, that this crest of the Sulina bar remained essentially stationary, so far as any outward movement is concerned, during the twenty-eight years that elapsed between the two periods of survey.

Further, the sea-shore line at the mouth of the Sulina is also stationary, and we do not find any recent delta-formation at its mouth. The characteristic of a delta-forming river is the constant annual extension of the shores at its mouth, the constant advance of the crest of its bar and of the whole bar, and the constant annual advance of the deep channel inside of and behind the bar. None of these characteristics are found at the mouth of the Sulina, which has long since ceased to be a delta-forming river.

But the Sulina bar has many of the characteristic conditions existing at the mouths of the little rivers emptying into the northern lakes, where the Engineer Department has constructed harbors by using two piers or jetties. Thus, at Chicago there was a depth of only two or three feet on the bar at the mouth of the Chicago River. Parallel piers were built there, and at the first spring flood following their construction a channel of considerable depth was scoured out. That was the commencement of the present fine harbor at that place. There is a shingly shore north of Chicago, and hence large annual accretions behind the north pier. The Chicago River is not muddy.

There is another distinguishing difference of characteristics between the Sulina bar and the bar of a delta-forming stream. During the flood-condition of the Danube the crest of the bar of the Sulina is deepened by the current, but is shoaled again when the flood subsides. On the contrary, the crests of the bars at the mouths of the Mississippi are never materially deepened by the river-flood, but the annual extensions of the bars seaward then take place, and these extensions or additions to the bars are as shoal as the crest, the shoalest part.

The quantity of earthy matter held in suspension and thus carried to the sea by the Sulina is also very small, compared to that of the South Pass of the Mississippi River, the smallest of the passes. In the case of the Sulina we perceive the efficacy of the littoral current moving southward; that is, toward the outlet of the Black Sea, the Bosphorus. It carries off the earthy matter while it is held in suspension, but does not remove the deposits made by the Sulina; for, as before stated, the lit-

toral current does not extend downward to the sea-bottom or shoal, but is found at the surface of the sea, and for a few feet below the surface, consequently it has no influence at all upon the earthy matter pushed along the bottom of the Sulina by its fresh-water volume, which moving matter is deposited where the fresh water rises on the salt water.

Now, the earthy matter held in suspension by the Mississippi River is mainly kept in suspension by the horizontal and vertical irregularities of the bed, (see page 139, Report on Mississippi River,) which constantly stir it up so long as these irregularities exist. When these vertical and horizontal irregularities diminish, the quantity of suspended matter diminishes, some of it falling to the bottom; and when these irregularities cease altogether, the greater part of the suspended earthy matter begins to fall to the bottom. In the vicinity of New Orleans the material thus dropped, which is drifting along the bottom, is the same kind of material as the sediment held in suspension, no coarse material being carried or pushed by the river past this point. Below New Orleans the course of the river varies but little, and its cross-section becomes much more uniform than above; as a consequence the sediment falls to the bottom in much larger proportion in this section of the river than above.

The horizontal and vertical irregularities of the bed cease almost entirely where the Southwest Pass begins to widen, 7.3 miles from the crest of the bar, and from this point seaward the suspended sediment falls to the bottom at a nearly uniform but slowly decreasing rate for twenty or thirty miles. The greater part of it is deposited on the bottom of the Gulf between the crest of the bar and a point about ten miles seaward. Some of it is carried farther seaward. A part, as above stated, is dropped upon the bar, commencing where the pass begins to widen, and, during the high-water stage of the river, is pushed along, with the other earthy matter there, to the crest of the bar, and forms part of the material which extends the bar annually into the Gulf. When the river is in a low stage the earthy matter dropped on the bar remains there, subject only to the feeble Gulf currents of the salt water, which then flow in and out over the bar underneath the fresh-water surface-current.

It is perceived from this explanation that there are two separate, distinct bar-formations at the mouths of the Mississippi River; the one formed by the earthy matter pushed along the bottom of the river and bar, which is the formation known by every one as *the bar*, the obstruction to navigation; the other formed by that part of the earthy matter held in suspension, which lies where it was dropped outside, or seaward, of the first-described deposit, or bar.

Although this last deposit does not, itself, obstruct navigation directly, yet it plays a very important part in causing the obstruction, since it converts the deep water of the Gulf into shoal water, and thus prepares the bed upon which the annual advance of what is usually termed the bar, is made. The one bar is formed by being superimposed upon the other.

In the case of the Sulina improvement, the annual seaward accretions to the crest of the old bar, made by the earthy matter pushed along the bottom of the river, were always very small, and, as the jetties now throw the suspended earthy matter well into the littoral current, a large part of it is carried away from the mouth of the stream, and hence the shoaling due to the deposit of the remainder (which is not carried away by the littoral current) is much slower than formerly. The earthy matter pushed along the bottom of the river appears to have always been so small in quantity, as not to have had any controlling power over the bar-

formation. It is now carried by the action of the jetties (which extend into deep water) into comparatively deep water, and adds some additional material to the deposit made by the suspended earthy matter.

In the case of the mouths of the Mississippi River, even at the mouth of the smallest pass, the quantity of both kinds of deposit-matter is enormous, and there is no littoral current to carry the suspended matter away. Even if there were at the mouths of the Mississippi a littoral current of the force of that existing at the Sulina mouth of the Danube, (the most careful observations have, however, failed to detect the existence of any at all,) it would be utterly impotent to cause any material modification of the bar-formations.

It may be remarked here that the distance which the currents of a delta river extends into a tideless or nearly tideless sea depends more on the volume of the river than the velocity of the current. The velocity of the current being the same in the one case with a small volume, and in the other with a large volume, in the first case the current will soon be neutralized, while in the other it will extend for miles into the sea before it is brought to rest.

From the foregoing it is apparent that the Sulina bar of the Danube has no resemblance to the bars at the mouths of the Mississippi River, and that what they have been dealing with in the improvement of the Sulina is a bar or shoal derived chiefly from the deposit of *earthy matter held in suspension* and not *earthy matter pushed along the bottom of the bed of the Sulina*.

A very important question connected with the jetty system is the rate at which the bar will advance under the influence of jetties. This, it seems to me, is not difficult of solution. The principles which should guide the application of this system are enunciated in that portion of the report of Humphreys and Abbot upon the Mississippi River, submitted August 5, 1861, which treats of the mouths of the river, especially the sections under the captions of "*experimental theory of the formation of bars*," and "*recommendations for improving the navigation at the mouths*."

The following is extracted from the latter section, pages 455 and 456 :

The development of the laws which govern the formation of the bars has removed all uncertainty as to the principles which should guide an attempt to deepen the channels over them. The erosive or excavating power of the current must be increased relatively to the depositing action. This may be done either by increasing the absolute velocity of the current over the bar, or by artificially aiding its action. To the first class of works belong the jetties and the closure of lateral outlets ; to the latter, stirring up the bottom by suitable machinery, blasting, dragging the material seaward, and dredging by buckets. These plans are all correct in theory, and the selection from them should be governed by economical considerations.

If the excavating power and depositing action of the Southwest Pass had been equal when the yearly advance of the bar was 700 feet instead of 338 feet, the least depth upon it would have been 21 feet. This increase of excavating power may be obtained by constructing two converging jetties, beginning where the depth of 22 feet is found, and extended to that depth outside the crest of the bar, which would give them a length of about 2.5 miles. The experience gained in the progress of the work should determine where the convergence should cease and the parallelism begin. The erosive action should be aided by first dragging and scraping the hard portions of the bar. The depth of 21 feet thus obtained must be maintained by the annual extension of the jetties 700 feet into the Gulf, and the reduction of the mud-lumps by suitable machinery whenever they begin to appear.

But it appears to be desirable to go somewhat more into detail in this explanation. Accordingly, taking the Southwest Pass as a model, and taking the dimensions of the careful survey of 1838, we find that it has a mean width of 1,200 feet and a mean depth of about 60 feet. About seven miles before reaching the crest of the bar the channel begins to

widen and the depth to decrease, and they continue to do so until at the crest of the bar the width is 11,500 feet, and the mean depth, from having been 60 feet, is but 11.5 feet.

An addition of 338 feet is made to the bar every year along the whole line of the crest, 11,500 feet long. This is the annual extension into the Gulf. This addition or extension has the same mean depth of water on it as the crest, 11.5 feet. If we go back from the crest of the bar toward the point where the pass begins to widen, we shall find a depth of 21 feet in the channel-way, where it is about 6,000 feet wide.

The same bulk of earthy matter is, in a series of years, added to the bar annually, and if it be added to it on a line 6,000 feet long, instead of 11,500 feet long, the seaward length of the addition must be about twice as great, (the depth of water upon which this addition is made being substantially the same in each case;) that is, the bar, instead of being extended 338 feet into the Gulf annually, will be extended twice that distance, or about 700 feet.

If we refer to the channel where it is 25 feet deep, we find the width to be about 4,000 feet; and the mass of the annual addition to the bar being the same, the annual extension on a front of 4,000 feet, instead of being 338 feet, will be about 1,000 feet, and this will be about the annual extension of the bar for a depth of 25 feet if the jetties are suitably arranged for that depth. If they are at a greater distance apart, the depth will be less than 25 feet. If they are at a less distance apart, the depth will be greater, and, the addition to the bar being formed on a less front than 4,000 feet, will have a greater annual extension than the bar formed on that front. So that in applying jetties to permanently deepening the bar of the Southwest Pass to 25 feet, we must expect an annual extension of the bar of about 1,000 feet.

Examining the map of the bar, we find that the horizontal distance between the part of the channel (inside the crest) where the depth is 25 feet to the point in the channel (inside the crest) where the depth is 21 feet, is about 4,000 feet, and we have every reason to conclude, and not one reason for a contrary conclusion, that if the jetties are not extended after obtaining a depth of 25 feet, in four years' time the bar will have extended into the sea about 4,000 feet, and, following the law under which it has heretofore been formed, the depth on its crest will be 21 feet; that is, the bar-accretions will be made on a slope rising at the rate of 1 foot per every 1,000 feet of accretion.

The conclusion is inevitable: the jetties must be extended annually at the same rate that the bar is advancing, if we intend to maintain permanently the same depth upon the bar.

If the depth to be maintained is 27 feet at low water, or 28 feet at high water, it will be found by a similar process that the annual advance will not be less than 1,200 feet.

The jetties may be so arranged as to cause a greater depth than the one required, and thus obviate for a time the necessity of their annual extension into the Gulf, but such an arrangement will entail a proportionately greater first cost in their construction. The final result as to cost and depth will be the same whether the jetties be converging or parallel, and the parallel has therefore been assumed as the model in this discussion.

Some engineers have adopted the opinion that the jetties, by increasing the strength of the current largely, will carry the earthy matter forming the bar so far out and into such deep water that there will practically be no necessity for extending the jetties after the desired depth has been once obtained. This view is derived from the supposition

that the bar is formed by the check which the current of the river-water receives in entering the Gulf; which check, it is said, reduces its velocity so much that the earthy matter carried in suspension by the river-water is dropped at once into the Gulf and forms the bar. This was the opinion usually held by engineers in former times, but was not based upon any measurement of the currents or careful observation upon them. It was known that the river-current was brought to rest in the sea, and it was assumed that, at the point where it *apparently* entered the sea, (that is, where its banks were salt water instead of earth,) a sudden and great reduction in the strength of the current took place, much greater than occurred at any other point of its prolongation into the sea. But those who have carefully examined the mouths of the Mississippi River, or who have examined the series of current-observations made there under my direction, perceive that there is no material check to the river-current as it enters the Gulf, and that it requires exceedingly nice measurement to detect any change in this velocity over long distances. In fact, the current of the river is retarded at a very slow rate from the point where the pass begins to widen, seven miles inside the crest of the bar, until it is brought to rest, some twenty miles or more seaward of the crest, at high-water, and some ten miles or more at low-water, making the whole distance before it is neutralized twenty-seven miles or more at high-water and seventeen or more in low-water. And along those distances of twenty-seven miles in high and seventeen in low-water it drops the suspended earthy matter at a nearly uniform but slowly-decreasing rate.

These being incontrovertible facts, the questions next occur, where does the material come from that forms this great deposit which adds annually 338 feet to the bar of the Southwest Pass, with a depth upon it of $13\frac{1}{2}$ feet at low-water? and why is this material, wherever it may come from, deposited in juxtaposition to the old bar on the seaward side?

Two observed facts put together answer these questions clearly. The first, the ascertained fact, already mentioned, that throughout the whole course of the river there is a mass of earthy matter pushed along the bottom of the river, (not suspended in the water,) moving at a much slower rate than the current of the river. At the mouth of Red River, two hundred miles above New Orleans, this material was chiefly small gravel and coarse sand; not far below Red River, coarse sand and small balls of blue clay; still lower down, coarse sand; and in the vicinity of New Orleans, at all stages of the river, chiefly sand and earthy matter, the same kind of sediment as that found in suspension at that point, the sand being very fine. No coarse material passed this point of the river.

The second is the ascertained fact that, where the fresh-water current of the river meets the salt-water of the Gulf, the fresh water rises upon it, and creates a dead angle of salt-water on the seaward side of the bar; and when the earthy matter pushed along the bottom of the river arrives at this point, the fresh water having risen from it, there is no longer any pushing force to keep the earthy matter in motion. It remains in the still salt-water, forming an accretion to the bar. Its upper surface lies along the slope, on which the fresh water moves upward upon the salt-water, which repeated measurements upon the bar of the Southwest Pass prove to be (on that bar) a slope of one foot in a thousand. It can make no difference whether the river-current be moving at the rate of 4 feet, 3 feet, or 2 feet per second, when it reaches the point where it

risers on the salt-water, the matter pushed along the bottom will come to rest in the still salt-water substantially at the same point.

We have seen that no coarse material is carried or pushed by the river past New Orleans, the drifting material there being of the same character as the suspended matter. Fifteen miles below New Orleans a marked change takes place in the river; its course to the sea varies but little, and its cross-section becomes much more uniform than above, and, as a consequence, the suspended matter falls to the bottom in larger proportion than above New Orleans. The sedimentary matter thus dropped to and pushed along the bottom of the river during high-water to the point where the pass begins to widen, and thence to the outer crest of the bar, forms a part, but not the whole, of the annual accretion of the bar. That portion of the suspended sediment dropped in high-water on the seven square miles of the bar, and swept to its outer crest, forms another part of its annual accretion.

Respecting the character of the material composing this bar, George G. Meade, one of Captain Talcott's principal assistants, who had charge of that portion of the survey of 1838 comprising the Southwest and South Passes, says of the bar of the Southwest Pass:

The bar is composed of mud and sand, the matter held in suspension by the river-water. Within and without the shoal the bottom is soft mud of a bluish and yellow tint, having a large proportion of alumine. Immediately on the shoal the bottom is harder, and has a greater proportion of sand.

Respecting the South Pass he states:

The bottom is generally sand, interspersed with spots of soft mud. The bottom on the bar is principally fine gray sand, mixed with a small proportion of mud. Without the shoal the soft yellow and blue mud of the passes is found. The character of the bar is sand, as it is of the passes and of the adjacent shoals.

Let us see what changes, if any, would take place in the amount of suspended earthy matter dropped between the point where the pass begins to widen and the crest of the bar, if jetties were constructed so as to give 28 feet water.

Half-way between the point where the pass begins to widen and the outer crest of the bar, we find (map of 1838 taken as the model) in the middle of the channel a depth of 28 feet at high-water for a width of 1,800 feet. Jetties properly constructed from this point to a similar depth outside the crest of the bar would give the required depth of channel-way.

It has already been pointed out that the greater part of the suspended earthy matter begins to fall regularly to the bottom as soon as the horizontal and vertical irregularities of the channel-way cease; and if the volume of discharge passes between straight jetties, of uniform distance apart, with a uniform cross-section throughout their length, we have the conditions favorable to the falling of the suspended matter to the bottom.

Now, all the earthy matter pushed along the bottom of the river above the point where the pass begins to widen, and all that dropped below that point for one-half the length of the bar, (where the jetties are supposed to begin,) will be pushed along the bottom between the jetties to the outer crest of the bar; and all the suspended earthy matter that drops to the bottom throughout the length of the jetties (one-half the length of the bar) will also be swept there. How much, it will be asked, would this last quantity (the suspended earthy matter dropped to the bottom throughout the length of the jetties) differ from the quantity dropped on the last or outer half of the bar if there were no jetties? The difference is indicated by the difference in their mean velo-

cities, so far as the quantity of deposit is dependent on the mean velocities, and should be inversely as those velocities; that is, the quantity dropped on the same length would be between one fifth and one-sixth less between the jetties than on the lower half of the bar. Compared to the whole quantity dropped on the bar it would be about one-eighth less.

It has been recently stated by a civil engineer, in a pamphlet concerning the improvement of the mouths of the Mississippi River by jetties, that the amount of sedimentary matter carried in suspension by the Mississippi River is in exact proportion to the velocity of its current; and that, as a given velocity of current will keep in suspension a corresponding quantity of solid matter at a less velocity, a certain portion of it will be dropped. To illustrate this he states that—

When the Bonnet Carré crevasse occurred, the river below it (107 feet in depth) was shoaled up 31 feet, because the volume of water in the river, being lessened by the crevasse, was no longer sufficient to maintain the normal current in a channel large enough to carry the entire river, consequently the current below the crevasse slackened, and the excess of load was dropped in the channel until the bottom was filled up 31 feet with the deposit. This reduction of channel was sufficient to re-establish the current and prevent further deposit.

The first statement is in direct conflict with the results of the long-continued measurements made upon the quantity of earthy matter held in suspension by the Mississippi River at Carrollton, near New Orleans, and at Columbus, twenty miles below the mouth of the Ohio, one of the chief objects of which was to determine this very question, whether any relation existed between the velocity and quantity of earthy matter held in suspension. These results prove that the greatest velocity does not correspond to the greatest quantity of earthy matter held in suspension; on the contrary, at the time of the greatest velocity of the current at Carrollton the river held in suspension but little more sediment per cubic foot than when the velocity was least. When the quantity of earthy matter held in suspension was greatest the velocity was two feet per second less than the greatest velocity, the quantity of earthy matter in the one case being three times as great as in the other. We find at another time, when the velocity was one-half the greatest velocity, the quantity of earthy matter held in suspension was double in amount.

At Columbus we find similar conditions existing. At the time when the greatest quantity of earthy matter was held in suspension, the velocity was less than one-half the greatest velocity; and at the time of the greatest velocity the quantity of earthy matter in suspension was one-half the maximum quantity. Again, we find a time when the quantity of earthy matter in suspension was nearly the same as the maximum, the velocity being less than one-third of the greatest velocity. Again, we find the quantity of earthy matter in suspension the same, the velocity in the one case being 6.75 feet per second, and in the other 1.5 feet per second.

The following tables, illustrating what has just been said, have been prepared from the report on the Mississippi River. The figures given express the conditions existing not only on the one day noted, but on several successive days.

During the whole period of observation the river-bed remained unchanged. It will be noticed that even the maximum amount of sediment in the river-water is a very small quantity compared to the mass of water, it being by weight in the proportion of one ounce of fine earth to six hundred and eighty ounces of water; and by volume one cubic inch of earthy matter to one thousand three hundred and sixty cubic inches of water.

It is to be remarked that the investigations respecting the sediment in suspension show that the quantity depended on the river from which the volume of discharge was at the time chiefly derived.

1.—Carrollton, 1851.

Date.	Weight in grains of sediment in one cubic foot of water.	Mean velocity of river, in feet, per second.	Remarks
February 20	450	6.5	{ Change in velocity regularly decreasing, while matter suspended remains the same.
March 20	200	6.2	
April 15	150	5.6	
May, (last week of)	100	3.75	
June 20	650	4.3	
July 10 to 30	450	4.8	
August 1 to 20	450 {	From 4.8 {	
September 8	300 {	to 2.5 {	
October and November	100	3.0	
December	175	1.75	
January 20, 1852	400	1.85	
		2.75	

2.—Columbus, twenty miles below the mouth of the Ohio, 1858.

Date.	Weight in grains of sediment in one cubic foot of water.	Mean velocity of river, in feet, per second.	Remarks.
April 1	300	7.00	Uniform decrease in amount of sediment, the velocity remaining the same.
April 10	300	5.25	
April 25	450	7.25	
May 1	300	7.50	
May 10	200	5.75	
May 22	160	6.75	
June 16	330	8.25	
July 16, 17	650	3.75	
August 2	350	4.75	
August 9	250	4.00	
September 2	600	2.50	
September 9 to 23	200	2.25	
October, (all of)	200 to 100	1.50	

The cross-sections both at Carrollton and Columbus remained unchanged during the above observations.

The statement concerning a deposit below the Bonnet Carré crevasse is also in direct conflict with ascertained facts. (See pages 387, 388, 389, 390, and 393, Report on Mississippi.)

This statement concerning a deposit being formed below the Bonnet Carré crevasse was made just before the survey of the Mississippi Delta was begun, and was carefully investigated in the course of that survey. The subject had an important bearing upon the question of using outlets to reduce the floods. It was found there had been no deposit whatever below the Bonnet Carré crevasse, and that the bottom of the river there was composed of hard blue clay, of older formation than alluvion, and that the cross-section had unquestionably remained unchanged.

Reference is also made in this pamphlet by its author to certain experiments by Prof. E. W. Hilgard, of the University of Michigan, who "has classified silts according to the different velocities at which they deposit," as confirming the views expressed that the sedimentary matter carried in suspension by the Mississippi varies precisely with the velocity of current. The classified table of Professor Hilgard gives the relative velocities created in a mechanical contrivance made for test-purposes in a laboratory, in which coarse sand is dropped at a certain velocity of the machine, which may be represented in nature as a current of about $2\frac{1}{2}$ inches per second; the finest sand when the current is 0.3 of an inch per second; the coarsest silt when the velocity is 0.14 of an inch per second; the finest silt when the velocity is about 0.02 of an inch per second.

If these experiments of Professor Hilgard had any application to the Mississippi River, they would prove that there could not possibly be any addition to the bar, where it is added to every year with a current of 3 feet per second running over it and seaward of it; and they would prove that there could be no bar until the current of the river was reduced to a rate varying between $2\frac{1}{2}$ inches per second and 0.1 of an inch per second, that is, some fifteen or twenty miles further seaward than it is now. They would prove, also, that there could be no deposit in the Gulf just seaward of the bar, where there has been a deposit 70 feet thick since 1838. It is unnecessary to pursue this subject further.

But, it is said by some, the construction of jetties will at least carry the earthy matter held in suspension so far seaward that the thickness of the deposit formed by this matter on the bottom of the Gulf will be largely reduced. It seems to me that this opinion has been adopted without careful consideration. Taking the Southwest Pass as a model, an examination of the processes going on there will make it apparent that the earthy matter in suspension will, in the event of the application of parallel jetties to deepening the bar of that pass, be carried further seaward of the crest of the bar than it is now carried by just the length of the jetties built. If these are intended to give 21 feet at low water, the earthy matter in suspension will be deposited over a length about two and a half miles longer seaward; that is, instead of being deposited on a length of ten miles, it will be deposited on a length of twelve and a half miles; if 25 feet depth is to be had, that matter will be deposited on a length of about thirteen and a half instead of on a length of ten miles. But the width of the area on which it will be deposited next to the outer crest of the bar will be proportionally diminished at precisely the same rate. Instead of being 11,500 feet wide there, it will be one-half that width in the case of 21 feet depth, and one-third that width in the case of 25 feet depth. The area of deposit, and consequently the thickness of deposit, will remain substantially the same.

According to the measurements of Captain Howell, the annual advance of the bar of the Southwest Pass during the past three years has been about 400 feet. The rate given in the report on the Mississippi River by Humphreys and Abbot, 338 feet, was deduced from a careful comparison of Talcott's large-scale map of 1838 with that of the Coast Survey of 1851. A comparison of Captain Talcott's map, from his survey in 1838, with Captain Howell's map, carefully prepared from soundings in December, 1873, and January, 1874, shows that the bar has advanced into the Gulf between the dates of those surveys nearly 11,000 feet.

Between these dates there were at least two years when the bar did not advance appreciably; they were the two great drought-years of 1855

and 1856, which prevailed all over the country. In 1855 there was no high-water at all. The river at New Orleans remained in low condition during the whole year, rising but once for a brief period to about half the ordinary height attained annually. At no time during the year was there any river-water in contact with the bar, and there was no accretion to the bar. In 1856 there was more volume in the river than in 1855, but there was no high-water, and it is probable that the bar advanced but a few feet during that year, if it advanced at all.

A comparison of the most recent measurements with those of 1838 gives no reason for adopting any new rate of advance for the bar at this pass.

I have prepared an estimate of the cost of applying jetties to the Southwest Pass Bar to obtain 27 feet at mean low-water, or 28 feet at mean high-water, the structures to extend down to the full depth of 23 feet at high-water. The cost is \$7,000,000.

If the jetties were simply built upon the surface of the bar, and not extended downward, their cost would be about one-half that sum. This mode of construction has been suggested by some engineers, and would be suitable if a long time were allowed for the erosion of the channel-way to the required depth. But this erosion must take place in a short time, and must be controlled by the jetty-structures. Hence the necessity of their being carried down to the depth of the intended channel.

The annual cost of maintaining the depth by extending the jetties according to my estimate will be about \$1,000,000, which, considered as interest at 6 per cent. per annum, represents a capital of \$16,000,000. This, added to the first cost of my estimate, gives \$23,000,000 for the expense to the Government of securing a permanent depth of 27 feet at mean low-water.

To secure the same depth by constructing and maintaining a canal will cost \$13,000,000.

Respecting the practicability and cost of the canal, it is incumbent upon me to say that the officers comprising the board to which the subject was submitted are among the ablest and most experienced in the Corps of Engineers.

Regarding the practicability of the canal, I desire to make a brief extract from the report of Captain Talcott, a distinguished officer of engineers, transmitting the maps of his survey of 1838. He states that he bored to the depth of 40 feet on the line of the canal proposed by Major Chase, and found—

Firm bottom of sand mixed with mud, tenacious of water, and altogether such as would be considered favorable for excavating, and on which there would be no difficulty in securing a foundation for locks or structures of any kind.

SOUTH PASS.

From the results of Captain Howell's recent soundings on the bar of the South Pass and seaward of it, I have deduced that the advance of the outer crest of the bar since 1838 has been 3,900 feet, or at the annual rate of 111 feet. Comparing the map of 1838 with the Coast Survey map of 1867, the advance was 3,220 feet, or at the annual rate of 111 feet. Comparing the Coast Survey map of 1867 with his recent soundings, the advance is 680 feet, or at the annual rate of 113 feet.

In preparing the Report on the Mississippi River, (in 1860-'61,) the advance of this bar was determined by comparing the Coast Survey map of 1851 with the map of 1838, and was found to be, in that time, (thirteen years,) 3,640 feet, or at the annual rate of 280 feet, which was

the rate adopted. The printed comparative maps have been examined again and give the same result, but it is apparent that there was some error in the Coast Survey map of 1851, and the annual rate of 111 feet should be adopted for the advance of this bar, though there is still some uncertainty as to this rate.

The mean width of the pass is 700 feet, but a less width for the jetties must be taken if a channel-way of suitable width with a depth of 27 feet at low-water is to be obtained. Assuming 500 feet for this width; then, as the width of the bar where the annual accretion of 111 feet is made is 3,000 feet, we shall have, with jetties 500 feet apart, an annual advance of 670 feet.*

The estimated cost of jetties to attain 27 feet depth at mean low-water at this bar, the structures extending to and below that depth, is \$4,150,000; the annual cost of maintaining this depth is \$670,000, which annual expense represents a capital of \$11,000,000, the two sums amounting to \$15,250,000.

To this estimate must be added the cost of dredging in those parts of the pass where there is less than 27 feet depth, and opening and keeping open the pass through the shoal at its head, on which there is now a depth of only 12 feet.

Captain Howell estimates that the annual cost of this will exceed \$100,000. The total cost to the Government of securing permanently a depth of 27 feet at low-water by this pass will then be about \$17,000,000.

From my having had charge formerly of the survey of the Mississippi River, made in pursuance of acts of Congress, one of the objects of which was to ascertain, by actual measurement and other experimental researches, in what manner the bars were formed and how the channels at the mouth through them could be deepened, I have felt compelled to present my views upon the jetty-system somewhat in detail, the more particularly as that portion of the report upon the physics and hydraulics of the Mississippi River was not as fully elucidated as it would have been under different circumstances, the report having been brought to a close in August, 1861, in the midst of all the disturbances of the early part of the war.

As the minority report of the board on the Fort St. Philip Canal contained much that was of the character of a review of the majority report, I should have reconvened the board and referred the minority report to it for consideration, but for the urgent requests made by members of Congress for the immediate transmission of the reports to the Secretary of War for submission to Congress.

Having received from Lieut. Col. John Newton, the ranking officer of the majority, two carefully-prepared papers touching the minority report, I transmit them herewith, recommending his views to careful consideration.

I beg leave to recommend that these papers be transmitted to the House of Representatives with this report.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers.

Hon. W. W. BELKNAP,
Secretary of War.

* According to Howell's map of 1874, received after this report was made, the length of the crest of the South Pass Bar is 4,000 feet. Its length, according to Talcott's map of 1838, was more than 5,000 feet. The annual advance of the bar is 100 feet, not 111 feet.—A. A. H.

Papers relative to minority report of the Board of Engineers, by Lieut. Col. John Newton, Corps of Engineers.

[No. 1.]

UNITED STATES ENGINEER OFFICE,
New York, March 11, 1874.

GENERAL: The Board of Engineers convened by Special Order No. 83, dated Headquarters Corps of Engineers, Washington, D. C., June 30, 1873, to consider and report upon the plan submitted in compliance with a resolution of Congress, by Capt. C. W. Howell, Corps of Engineers, for a ship-canal to connect the Mississippi River with the Gulf of Mexico, having already rendered their report, which has been made the subject of certain comments by a member who had dissented from the opinions of the board, it has seemed proper that, having signed that report, I should attempt to correct the misapprehension that there exists a material, if any, difference between the views of the board and those of the member alluded to upon the subject of the ship-canal.

Before I have done I will state what the board did recommend, and what relation such recommendations bore to the whole project of Captain Howell; but it is first necessary to a correct understanding and appreciation of the matter that certain points of the history of the proceedings of this board should be touched upon.

1. The first report of the Board, which it was directed should be in Washington by the 15th of last December, was written by one of the members after the adjournment of the board at New Orleans, which adjournment, it must be said, was hastened materially on account of instructions received by several of the members to repair to their works, in view of a supposed national exigency. The report thus prepared was sent to the different members for their signature, and it received naturally a good many emendations, though in nothing affecting its essential matter. Owing to the close proximity of the 15th of December, nothing could be done except to make these emendations in pencil, and so transmit it to Washington, with a letter explanatory of the necessity for this proceeding.

Accompanying this report of the board was a minority report by the same member. Although these reports have been replaced by others from their several authors, yet as the author of the minority report has, in his later papers, referred to and quoted from his first report, I will exercise a similar right.

With the majority of the board I concur in the opinion of the practicability of the work in an engineering point of view, but at the same time believe the execution to involve difficulties of a serious and unusual character for which engineering construction yet made in this region, or in this country, offers no precedent. These difficulties are due to the character of the soil in which the work is laid. One of the important questions, and one which at the very first presented itself to the members of this board, is the stability of the prism, i. e., the self-maintenance of the bottom and sides of the canal-excavation. No one of the experienced Louisiana engineers whom we have consulted has professed to be able to give a decisive answer on this. The subject is more particularly treated in the letter of Professor Forshey, (appended.)

Existing canals cut to depths of 6 feet through the swamps and ravines, and of 12 or even 18 feet high and well-drained marginal river soils, (as the Barataria and La Fourche Canal,) do not tell what will happen when we excavate 25 feet and more on the site of the proposed canal. I entertain no real apprehension that the prism cannot be ultimately made stable; but the process by which this result will come about I do not foresee nor define; and I only remark how vague and uncertain must be the estimate which computes the accomplishment of this result at 50 cents per cubic yard of excavation.

And in summing up in that report, he further says :

In conclusion, I have to express the opinion that the ship-canal project requires further study before plans and locations and modes of operations can be fixed and a reliable or even approximate estimate can be made; and I recommend : * * * Third, that the survey of the ship-canal be continued, and further studies as to locations and plans to be made; and in this connection one important experiment to make (in connection with multitudinous borings) would be a practical trial of excavation for the canal-prism for a length of one or two hundred feet.

In common with other members, I was strongly impressed, until the appearance of the report, which has been cited, that the dissenting member entertained an opposite view of the feasibility of excavating the trunk of the canal, which he based in part upon the successful excavation of the North Sea Canal to a depth of 7.50 meters through an alluvial soil.

The idea of this experimental prism was probably adopted from a suggestion by one of the signers of the report of the board, made prior to the visit to New Orleans.

The preliminary report of the board had previously recommended an appropriation, among other objects, to be used for determining "the best locations for locks and for the trunk of the canal." The second report of the board again refers the location of the canal to the result of future examinations and borings. The author, in his second minority report, not only makes no mention of any apprehended difficulties in the excavation and maintenance of the trunk of the canal, but even appears to fault the board with not determining the location of the canal until further borings and examinations should be made, and states :

Neither observation of, and familiarity with, engineering works in Louisiana, nor the borings made by Captain Howell, suggest to me that any material variation of its location will be suggested by further scrutiny of the substrata by boring.

On the question of maintenance of the side-slopes of the prism of the canal, there have been apparently, on the part of the dissenting member, two changes of opinion, and, on the question of the necessity for further borings, one change of opinion, so that on these points at least the board cannot be said to have disagreed with him.

The only difference between the dissenting member and the board, so far visible, is, he believes, "a more protracted and more comprehensive study is required to fix the location," while the board urges additional borings and examinations to be made as a preliminary to the determination of the best location of the canal.

2. The foundations for the locks are diffusively treated in the minority reports of December 6, 1873, and of January 29, 1874.

But there is no controversy on this score that I can discover between the board and the dissenting member, the board simply stating that the foundation can be laid by any one of several processes well known to engineers.

3. One of the paragraphs of the minority report is so worded as to leave it to be inferred that the grillage designed in the project laid before the board was approved by them. This is a mistake; the grillage was never approved.

4. The Board of Engineers, in their last report (printed) upon the canal project, arrive at the conclusion, "more particularly and pertinently from the character of the borings made by Captain Howell," that the construction of the canal is entirely feasible. "But it is suggested, in order to avoid beds and pockets of quicksand known to exist at some points in this locality, that the precise line of the canal should not be decided upon until a more thorough examination of the substrata has been made

by borings." The board thinks that such an examination may indicate the necessity not only of adopting a curve or series of curves for the axis of the canal, but also of selecting other points of termini than those recommended by Captain Howell; also "one member of the board is in favor of locating the Gulf terminus to the northward, and consequently under the lee of Sable Point, and of securing the requisite depth of water into Isle au Breton Pass by dredging. This would naturally carry the river terminus nearer to Fort St. Philip, and perhaps within suitable distance from the work to satisfy the requirements of a good defense without the erection of special works for that purpose."

Before drawing my inferences, I invite particular attention to conclusions 1, 4, 7, and 8 of that report. The borings made by Captain Howell being very few and far between, the board must have inferred the general character of the formation to be uniform, the number of borings otherwise not being sufficient to predicate anything upon, and, least of all, to sustain the conclusion of the board that the construction and maintenance of the canal presented no extraordinary engineering difficulties. Notwithstanding the minority report expends much space and time in the attempt to show that the board thought there were *material* variations in the character of the formations, the variations which the board say do exist are limited areas or *pockets* of quicksand, and it might have been said of soft mud, which, for the economical construction of the locks and trunk of the canal, it were expedient to avoid. The minority report, though embracing a long quotation from the report of the board, neglects to instance the subject above, though this alone would furnish a sufficient reason for demanding further borings. The minority report, however, afterward concedes this point in the following words:

The mobility of "the fine sand" where it exists, as it sometimes does, in strata almost destitute of clay, may, indeed, enhance the difficulties of making the canal trunk, and of getting through them to reach the lock foundation.

This acknowledgment is as much as could be desired.

5. Another reason for extended examinations was contained in the project of Major Warren; this being the *debouché* of the canal north of and under the lee of Sable Point. I send a tracing herewith, giving Major Warren's line of the axis of the canal. Major Warren's idea of a radical change of the location of the axis was explained to the board long before that of Colonel Barnard or of General Beauregard, and the minority report mistakes when it asserts that the idea originated with the latter gentleman. This may not be a matter of importance, but it is the fact.

It is clearly perceived, from this recapitulation, that an extensive field of investigation was laid out; the possible location of the canal along any line from Fort St. Philip down to or even below the line selected by Captain Howell, would include not only an examination of the land, but likewise of a certain area of the bottom of the Gulf.

6. If a line be adopted emerging into the Gulf north of Sable Point, which condition would carry with it the excavation in the water of a large portion of the trunk, no jetties would be necessary, and their cost, or a portion thereof, might be devoted, if considered necessary, to the construction of a breakwater against northeast and north storms. No protection from southeast storms would be required, the land serving as breakwater against them.

If the line of Captain Howell be selected, jetties would be required, and these should be spread apart at their junction with the land, and

inclined toward each other at their seaward extremities, after the usual mode of forming a harbor with piers. The direction of the axis of the canal being northeast, besides the harbor itself, there would be a considerable lee on the outside of the piers for the protection of many vessels of moderate draught of water against southeast storms. These considerations of the protection of shipping against storms are not now, for the first time, thought of; they formed the subject of discussion by members of the board, and were so evident that it was not considered necessary to incorporate them in their report. Such, at least, was my view at the time.

7. The necessity of fortifying the canal was likewise so evident that the board assumed it without discussion, and the only question in reference to it to be found in their report is whether the defense of the canal should depend upon existing works, or upon works specially constructed. No doubt has ever been expressed of the advisability of attaching the defense of the canal to existing works, provided other important points, among which was the permanence of the banks, which might involve the security of the foundation of the lock, could be adjusted suitably. General Beauregard says in his letter: "*Its (the canal's) location on the river should be under the protection of the guns of Forts St. Philip and Jackson, due regard being had to the permanency of the river-bank.*" (The underscoring is mine.) The permanency of the bank is the very point, for it has been represented to members of the board that encroachments upon one bank and fillings at the other are progressing at the bend, and in the neighborhood of Fort St. Philip. This state of things requires careful investigation before deciding upon the location of the canal near that fort.

8. The fact that the board had found it necessary to relegate the whole matter to the officer in charge for additional investigations before the location, even, of the canal could be satisfactorily settled, is a sufficient justification for their brief report, (if brevity in such matters is ever to be excused,) and for omitting to discuss further details, most of which will probably be solved by the examination recommended.

9. The line of canal recommended in the minority report furnishes a good lee against northeast storms, but not against southeasters. It would be ten and three-quarter miles long, of which eight and three-quarter miles would lie in the water. The navigation of a long, narrow channel, by vessels under the influence of side winds, would be difficult, owing to the constant tendency to drift upon the side of the excavation. I do not perceive how the cost could be less than that of Captain Howell's project, which is the most expensive of the various lines considered by the board; and, besides, our present knowledge of the bed of the Gulf in that locality is too limited to permit it to be assumed that the excavation of the trunk would be permanent. Investigations in the shape of *borings*, which the minority report will not join the board in recommending, appear to be necessary to solve the question.

10. The minority report, to sustain its views; quotes with approval from a report of the late Colonel Abert, in reference to the canal-project of the late Major Chase. The latter, in his report on a ship-canal said:

The obstacles presented to an easy entrance of the Mississippi by vessels drawing 12 feet of water are productive of great injury to the commerce of New Orleans, and require to be promptly removed; or, *failing to be done*, the construction of a ship-canal on the plan indicated by Major Buisson should be resorted to.

No wonder that the expense of the project, ten millions, should have turned Colonel Abert's views back to the methods of improving some

one of the passes, to ascertain whether 12 feet, or a little more, could not be obtained there.

In my opinion Colonel Abert was justified in rejecting the canal, because an adequate motive for its construction was wanting; while the passes could be improved easily to the depth then demanded. But if instead of 12 feet, the question had been of 25 or 26 feet in depth at the passes, would Colonel Abert have decided as he did? I think not.

11. No breakwater could be constructed in Isle au Breton Pass, in the neighborhood of the canal, on account of the damage and deterioration which might result to the pass itself from the structure; it might be placed south of Isle au Breton, but in order to protect vessels against storms, from southeast around to northeast, it would be necessary, if there was but one breakwater, to make it in the shape of an L, and this form would result in the filling of the interior space with silt, and considerable loss of benefit. I think the necessity for a breakwater, other than would be afforded by the construction of the outlet of the canal itself, has been much exaggerated. The storms from the southeast, which are the most violent, prevail exactly at that period of the year when the export trade of the Mississippi Valley is at its minimum. Against northeast storms, the lee of Isle au Breton, and of the shoals around it, would constitute a considerable protection. Large ships in that anchorage would ride out any ordinary storm, and it would be going too far to suppose that a navigator would allow himself to be caught in this cul-de-sac, when he might obtain due notice of the approach of a hurricane or cyclone. At all events, during the civil war our blockaders, composed mostly of merchant-vessels, were able to blockade continuously the ports of the Gulf, and even of the Atlantic coast.

During the prevalence of a hurricane or cyclone the protection afforded by a breakwater would not be of the slightest moment; vessels unable to enter a port on the approach of such storms have to run out to sea.

In a severe gale vessels cannot enter the passes of the Mississippi, Galveston Harbor, nor, I think, any harbor on the Gulf except the Tortugas.

12. It has been said that the board should have included the cost of defensive works in their estimate for the canal. The board have confined their action to the instructions given them, after a careful consideration of their scope; and, besides, it would have been impossible to estimate for defensive works when the location, even, of the canal had not been settled.

I understand that the defenses of Forts. St. Philip and Jackson have been planned under the supposition of there being a depth over the bar, at the passes, of about 18 feet, and that an increase to 25 feet, which is sufficient for the large class of iron-clads, would compel a considerable addition to be made to the present projects for those works; and further, that the cost of these additions would equal that of any defenses which it would be necessary to provide for the canal. Supposing the passes improved—as they cannot be defended by fortifications—the whole lower part of the river would be at the service of an enemy having a naval superiority. It is impossible, on the other hand, unless the canal be absolutely abandoned to the enemy, for him to make use of it. In the question of military defense, therefore, the canal is much superior.

13. The minority report appears to differ materially from that of the board, but this appearance is due principally to the fact that there are two reports discussed in the same paper—the project of Captain Howell,

and the report of the board—and from a certain inattention to precise arrangement the distinction between the two becomes obscure, and the reader is apt to mistake which party—Captain Howell, or the board—is criticised by the dissenting member. I have analyzed the supposed differences and give the result.

1. The board and the dissenting member consider a canal to be entirely practicable.

2. Both consider Isle au Breton Pass as suited for the outlet.

3. Both consider the peninsula of Fort St. Philip, below the fort, as the proper place for the other terminus.

4. Neither party would consent to place the terminus at a position where the river-bank was in danger.

5. Both desire the outlet to be near Sable Point.

6. Both consider that the canal should be under the protection of defensive works, and of existing ones, if possible.

7. There are no differences, of which I am aware, about the lock.

8. There was no controversy about foundations.

9. There was no controversy about location, because the board had not fixed one.

10. There is practically no difference about protection to vessels; and probably had there been a complete understanding between the parties, of their respective views, this present discussion would not have been necessary.

11. The dissenting member thought the width of the canal-trunk somewhat in excess, but two large vessels with a tow-boat on each side would take up nearly all the width; sidings, however, might be constructed for passage of vessels.

12. He, however, objects to the estimate put forward by the board because no sufficient data for an approximate estimate, even, in his opinion, exist.

It is proper to say that the board considered the location chosen for the project of the engineer in charge as representing the most costly in the amount of work, as well as in the requirements of protection of vessels; and adopted it for the above reasons, in order to fix, not an approximate, but a limiting, value to the estimated cost.

However, when he discusses particulars, he makes but one exception, viz, that of 50 cents per cubic yard for excavating the trunk of the canal, which he considers too little, in view of contingent difficulties; from the knowledge which various members had of the cost of dredging, the nature of the soil to be excavated from the canal, &c., they were of the opinion that 50 cents per yard would be largely in excess, and that said excess ought to be ample to insure against probable drawbacks.

As the minority report considers the character of the soil to be sufficiently known, and even that additional borings to test it are not necessary, the author would have doubtless gratified the board—I can speak at least for myself—by submitting his estimate for a canal, and such an attempt on his part would have been entirely feasible, claiming, as he does from professional experience, a knowledge of the difficulties to be encountered. The board, feeling that differences of opinion might arise on the subject of the improvement of the passes, and as the two subjects were radically distinct in their nature, decided to make the report on the canal separate from the other. Such a course it was thought would also have been more conducive to harmony of action.

Having carefully gone through the work of comparison, I have found the supposed differences to have nearly, if not quite, disappeared, and

am led to the conclusion that, for the canal project, there is not and has not been any important difference of opinion.

With regard to Captain Howell's project :

1. The board has not adopted his location, but has left this matter subject to results of future examination.

2. The board has not adopted his mode of constructing jetties.

3. The board has modified the dimensions and mode of constructing the locks.

4. The board has not adopted the coffer-dam and drillage for foundation of lock.

5. The board has adopted the dimensions of the trunk of the canal.

6. The board has adopted Isle au Bréton Pass for one terminus, and the straight reach of the Mississippi below Fort St. Philip for the other.

7. The board states the necessity for works of defense.

The dissenting member thinks that 2 per cent. on cost would represent the annual expenses of the canal, and this he derives from the Erie Canal, but the cases are not parallel, and I consider this percentage largely in excess; after the canal is finished and the work consolidated, I do not see how these expenses could exceed \$50,000 per annum.

I wish to state that, not having been able to consult the other members of the board, they are not responsible for the opinions I have expressed in this paper except where I have used the language of the report of board.

Respectfully submitted.

JOHN NEWTON,

Lieut. Col. of Engineers, Brevet Major-General.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers.

[No. 2.]

UNITED STATES ENGINEER OFFICE,
New York, April 3, 1874

GENERAL: I have respectfully to present some observations in review of the minority report, dated January 29 last, and offered to furnish the views of the dissenting member and the reasons for his non-concurrence with the report of the Board of Engineers, dated January 13, 1874, upon the subject of the improvement of the passes of the Mississippi.

STIRRING AND DREDGING THE BAR.

In 1852 a contract was made with the Tow-boat Association to deepen the Southwest Pass to 18 feet. It is stated that 18 feet was obtained in 1853, but it is not stated that the contractors were required to maintain this depth after it was once gained. It is stated in the minority report that the width of 300 feet was specified in the contract; but was it ever obtained? and, if so, where is the evidence?

The next example is the disbursement of \$330,000, appropriated by Congress, in 1856, for opening, and keeping open, by contract, ship-channels through the bars at the mouths of the Southwest Pass and Pass à Loutre. Contracts with the Messrs. Craig and Rightor were accordingly entered into for opening both channels to a depth of 20 feet, and maintaining that depth four and a half years. After constructing an apology for a jetty, the contractors abandoned that mode of operating to adopt

the system by stirring up, dredging, &c. By these methods they succeeded, September, 1858, in opening two channels to a depth of 18 feet, their contract having been modified that year with respect to depth. In the latter part of 1858 those parties refused to comply further with their contract to maintain a depth of 18 feet for a period of four and a half years. A new contract was entered into with other parties for deepening Southwest Pass, but they likewise failed to execute it.

The remainder of the appropriation, \$70,000, was then disbursed by the officers of the Department, and a depth of 18 feet was maintained upon the bar of Southwest Pass for one year.

In the first example taken the width is doubtful, while the element and cost of maintenance of the channel is entirely ignored.

The second example is deficient, by omitting the width; and the maintenance of the channel was not attempted.

In the third the maintenance of the channel for one year is stated, but the width is not. The importance of the omissions noted will be perceived by a little reflection upon the nature of the work itself:

1. The quantity of work will increase directly with the width and depth of the cut made in the bed of the channel.

2. If these dimensions exceed a certain limit, the slopes of both sides of the channel will slide into the excavation and increase the amount to be removed out of all ratio with the dimensions proper of the cut.

3. When a certain depth and width is obtained, the problem of maintenance then comes in. Some time is required for the grading of the sides, due to the new depth, and the maintenance is charged with the removal of these land-slips, as well as with that of the ordinary deposits in the channel.

4. Again, one season may be extremely favorable for the operations of excavating, due to the prevalence of a rapid current, while another, owing to the slack currents, may be very unfavorable.

5. In spite of all regulations the grounding of vessels must occasionally take place, and particularly if the cut is not made of *ample* width. The result of a grounding is the formation of a shoal in the channel-way and a loss of depth.

6. To these must be added filling up the channel excavated, and particularly the portion near the bar, by the influence of storms.

The conditions of the problem, as stated above, were considered, as well as the results obtained by Captain Howell during his operations from July 1, 1872, to April 1, 1873. At Southwest Pass the records show, by reducing mean low-water to extreme low-water,* that for eight days there was a depth of from 12 to 14 feet; for six days, 15 feet; for eight days, 15½ feet; for eighty-six days, 16 feet; for twenty-three days, 16½ feet; for twenty one days, 17 feet; for seventeen days, 17½ feet; for fifty-eight days, 18 feet; and for twenty-three days, 19 feet. That is to say, one hundred and sixty-nine days when the depth was less than 18 feet, to forty-seven days when it was greater than 18 feet; and it is a fact worthy of note that stoppages of work due to slack currents, rough weather, and to fogs, were mainly coincident with the prevalence of the lesser depths. These results should be consulted in preference to those given in the report of the board of January 13 last, as they are not only more in detail, but possess likewise the advantage of being reduced to extreme low-water of the Gulf, which is the standard adopted for the ship-canal, and used both in the reports of the board and those of the minority.

* This is not strictly correct. Extreme low-water, as observed in 1851-'52, Appendix A, Humphreys and Abbot, is lower by nearly 3 inches than the standard here assumed for purposes of reduction.

The time of two hundred and seventy-four days is accounted for as follows: Suspension of work on account of slack current, sixty-eight days; fogs, fifteen days; rough weather, fifteen days; repairs, forty-three days; Sundays, thirty-nine days; pulling off grounded vessels, four days; coaling, four days; leaving eighty-six days to be credited to the work of the machine, as no record exists to state that it was not at work. The result is one hundred and eighty-eight days of unavoidable suspension of work, to eighty-six working days.

The useful effect of the dredgers, measured in time, would, therefore, be only 31 per cent. of its theoretic value, and this result, taken from the records of the most improved machinery, constructed and worked under the eyes of engineer officers, if considered in relation to the fact before shown, that the amount of work under varying depths and widths of excavation may differ vastly from their numerical ratio to each other, shows conclusively that there is a practical limit of improvement by this process, which is suddenly reached.

The official records thus analyzed would not warrant the board in estimating a greater depth than 18 feet at extreme low-water as capable of being *maintained* at the passes by means of the stirring process; and there would seem to have been some reason for all former trials having been arrested when the depth of 18 feet, or about that depth, was obtained, as if the real difficulties of the case had then begun to be encountered. However that may be, these significant coincidences do exist.

It should have been stated in the report of the board of January 13 last that the depths obtained by Captain Howell at Southwest Pass are referred, not to extreme low-water, but to mean low-water, while the depths obtained at Pass à l'Ouvre from April 1 to June 30 are erroneously referred to "extreme low-water," instead of to mean low-water. This correction of the depth obtained at Pass à l'Ouvre would reduce it from $17\frac{1}{2}$ feet to about $16\frac{1}{2}$ feet. With nothing practical to rely upon save the records of the trials of 1853, 1858, and 1859, which are deficient in essential elements, and consequently useless for scientific investigation, the minority report does not hesitate to lecture the board in this wise:

In face of these facts; in face of the positive, formal, and official statement of the engineer in charge, that so far as regards obtaining a 20-foot channel the natural obstacles have been overcome, (reiterated under different forms,) and in face of the fact that since the proved success of stirring up by scraping with harrows, &c., for \$50,000 a year, machinery expressly designed to this end has been invented and improved upon, under the eye of engineer officers, to be operated at an expense of \$200,000 per annum, the majority of the board advise you that "the results so far do not warrant the board in estimating a greater depth than 18 feet at extreme low-water, as capable of being maintained at the passes by means of the stirring-up process;" and, furthermore, that this is inadequate to the requirements of the naval, military, and commercial services.

Let it be noted, first, that the engineer in charge does not state that he *maintained*, but only *obtained*, 20 feet of depth, and that depth was at mean, not at extreme low-water.

The necessity for this forcible if not courteous arraignment of the board by one of its members might have been spared if some little space had been devoted in the minority report to the recorded results of that "machinery expressly designed," * * * * "invented and improved upon, under the eye of engineer officers," and "operated at an expense of \$200,000 per annum." Now, although the records of the actual work of that machine at Southwest Pass had been collated by the board and published in their report, the minority report has not been tempted even to allude to them, far less discuss them.

Why the records of a past time so imperfect as to admit of any and every deduction have been relied upon to the exclusion of the full and precise information which could have been found in Captain Howell's last report upon the stirring process, is not in my power to explain.

One great objection to the moderate depth over the bar, which the dredgers are capable of yielding, is the fact that in rough weather it could not, on account of the swell, be availed of by vessels drawing the full, or nearly full, draught which the bar afforded, and at the very moment when an entrance is most needed. It is important likewise to remember that one effect of storms would be to create an actual obstruction at the bar by washing sand into the entrance.

It seems evident, from the above considerations, that, in order to make the navigation of the passes safe as well as convenient to commerce, something more than the bare draught of vessels must be considered in establishing the depth over the bar.

After the elaborate discussion of the benefits of the stirring process, and the conclusion that "with 20 feet at extreme low-tide," (which is *assumed* to be maintained,) "vessels drawing 22½ feet could, owing to the softness of the bar, frequent the port of New Orleans, and for mere commercial purposes probably 20 feet draught would be adequate; a draught of 23 feet will include 85 per cent. of the shipping of the world; and with a draught of but 18 feet vessels (steamers) can be built of 5,000 tons carrying 70,000 bushels of corn, or about 11,000 bales of cotton," I felt prepared to consider this as the settlement of the question on the part of the minority report, as well against the jetty system, which it advocates, as against the canal, which it reprobates. But no; however potent the argument may be against the latter, "still," (to use the words of that report,) "an improvement of one of more of the natural mouths by which a sufficient depth should be afforded without the continuous use of machinery * * would be desirable." As to defensive measures to protect the dredgers in time of war, none could be taken, unless vessels of war were detailed to this end; otherwise, without the necessity of a blockade, they would be at the mercy of every cruiser of the enemy which might choose to make a dash at them. Practically, therefore, dredging could not be carried on during a period of hostilities.

I feel no sympathy with the efforts made to demonstrate that the valley of the Mississippi would be sufficiently accommodated with a depth of entrance to its great river, so inferior to those of the principal ports of the country, believing that such depths will rule the draught of vessels frequenting our ports, and that a deficiency in that respect would make an unfortunate discrimination against the commercial prosperity of any locality.

Baltimore has felt this, and is now dredging to obtain a 24-foot channel leading to its port. I have from the first maintained that, leaving naval uses out of consideration, the necessities of commerce alone demand a depth of at least 24 feet at low-water for an outlet to the Mississippi, and nothing short of this will ever fulfill the conditions of the problem. The importance of making the Mississippi accessible to the larger classes of naval vessels cannot be overrated. It not only "furnishes a harbor of several hundred miles in length for vessels of any attainable dimensions and draught, but it furnishes in unlimited quantities, and at the lowest prices, all that is needed in ship-building, whether in wood or iron, and for the outfit of fleets and armies. To make the Mississippi, therefore, accessible to vessels of war, is to do away with the

need of other inefficient naval depots, such as that at Pensacola, and to furnish centrally to the northern coasts of the Gulf the much-needed depot and arsenal for naval operations."

The above, extracted from a paper submitted by Colonel Barnard, expresses forcibly the other (beside commercial) advantages which would be conferred by a liberal policy of improvement in this quarter.

A depth of outlet about 25 feet at extreme low-water would suffice to convert the Mississippi into such "depot and arsenal for naval operations," and I cannot, in view of the object which the resolution of Congress imposed upon the ship-canal, viz, to be suited for military, naval, and commercial purposes, agree to have an improvement of the passes (to take the place of the canal) discussed upon the idea of obtaining merely 18, 19, or 20 feet, a depth manifestly incapable of meeting the wants of the Navy.

The board discussed the canal project and the jetty system under the restrictions of the above resolution, and no discussion which ignores these can be considered to be either a review or reply.

IMPROVEMENT OF THE PASSES BY MEANS OF JETTIES.

The board of 1852 recommended, in the event of not obtaining sufficient depth by means of the stirring process at Southwest Pass, to resort to the system of jetties. Among those who signed that report was the member who has constituted the minority in this board. In a communication dated December 6, 1873, which has passed through the hands of the Chief of Engineers, he presents his views upon the improvement of the passes. He adopts Pass à Loutre as more favorable than Southwest Pass, apparently for two reasons:

1. A shorter distance from the interior depth of 25 feet to the outer crest of the bar.

2. A smaller annual advance of the bar into the Gulf.

As that paper has had an important share in shaping the form which the discussion of the improvement of the passes has since assumed, a brief synopsis of its plan of application of the jetty-system to Pass à Loutre will be useful:

1. The distance of the interior depth of 25 feet at low-water from the outer crest of the bar was assumed to be two and a half miles.

2. The natural width of the channel when that depth obtains was assumed to be one-half mile.

- "3. Parallel jetties starting from the cessation of 25 feet depth," (above the North Pass,) "closing this pass, extend a half mile apart, four miles to points opposite the outer crest of the bar, in about 10 feet water.

- "4. Perfect parallelism is not necessary. Large deviations may be made to select the best location.

- "5. Now, of the four miles on each side of jettying and leveeing combined, (for a large proportion of it should be called *levee*,) * * * two-thirds, perhaps three-fourths, may be laid on the ground bare at low-water, or permanently out of water. Of the remaining one-eighth or one-fourth, scarce any of it is in depth greater than 10 feet.

- "6. The average cross-section of jetties and levees is assumed to be 15 feet wide and 10 feet deep.

- "7. The effects of these embankments is described as follows: The 25-foot channel will be extended at once two and one-half miles * * the bar must be excavated to 25 feet. The velocity of current main-

tained unimpaired up to this point will carry its sediment far beyond into deep water. The present *régime* of a shoal-bed cannot again be restored until the vast bottom area, now covered with deep water beyond, for a distance of two and one-half miles, is raised.

"8. The jetties being once extended out to the crest of the existing bar, they do not require the incessant *following up* supposed; though that they may *ultimately* require extension, I do not dispute.

"9. I estimate that Pass à Loutre has advanced in twenty-nine years something over 200 feet per annum, say 225 feet. There seems no good reason for the assumption that the advance will be more rapid than can be easily dealt with, nor that continued and incessant work will be required.

"The very first operation is an advance of the deep channel *two and a half miles*, just twice as much as the bar has advanced in twenty-nine years.

"I feel that I am justified in recommending it (the jetty system) as *probably* furnishing the most speedy attainment of a deep-water channel, and one which will have some features of *permanence*; * * * and then illustrating the example of the Sulina mouth of the Danube.

"Indeed, the effect of the jetties has been the diminishing by more than one-half the old rate of the advance of the delta at the Sulina mouth as represented by the 24-foot line and 30-foot line of soundings, and this Sir Charles Hartley considers to be due to the circumstances that the great bulk of the silt-bearing waters of the river, on issuing, as at present, *at once into deep water beyond the pier-heads*, is, as a rule, carried far to the southeast by the littoral current, instead of flowing into the sea, as formerly, with a feeble and constantly-decreasing current, by numerous shallow channels, &c., and it was also found that the action of the sea on the bottom, during storms, swept away the banks deposited beyond the north pier-head.

"A 'littoral current' may not exist at the passes, but the efficient action of waves and currents produced by storms may be reasonably counted upon to retard, as they always have done, the rapid advance of the sedimental *déposite*, which, as at the Sulina, projected with undiminished velocity into the deep waters beyond the bar-crests, (at present the velocity has been nearly destroyed when the crest is reached,) will be disseminated far and wide."

These extracts offer a definite project for our consideration, and its author states, in express terms, the results to be expected from its construction.

1. Although he accepts a width of river between banks of one-half a mile, as corresponding to the depth required, *25 feet at extreme low water*, yet he advocates large deviations in excess of this width, in order to secure the best location for his jetties, and obtains by this novel, if not correct, mode of treating parallel jetties, the opportunity of making a presentation of his system sufficiently favorable in point of cost.

2. Notwithstanding his statement that the depth of 25 feet ceased to obtain above the division or fork of the pass, yet, in another and subsequent communication, he perceives no necessity of closing one of the outlets in order to obtain in the other the depth desired.

3. The result of such jetties, he asserts, would be not only to push forward the depth of 25 feet to the bar, but also to prevent the formation of a shoal depth over it until the deep space ahead in the Gulf, for a distance of two and a half miles, should first be filled. Afterward, to furnish some idea of the time required to accomplish this, he states

the distance to be filled corresponds to the progress of the bar for fifty-eight years.

4. It is not surprising, after the above, that he concludes the incessant following up of the bar, by extension of the jetties, to be superfluous, though he will not deny that ultimately they may require extension.

5. He appears to rely upon the precedent of the successful issue of the jetty-system at the Sulina mouth of the Danube as a guarantee for the application of the same method to the mouths of the Mississippi. But Colonel Stokes, of the royal engineers, and Sir Charles Hartley, the engineer of that improvement, both of whom were connected with it from commencement to completion, in their speeches and writings, concur in attributing whatever permanence may attach to the improvement to the existence of a *littoral current* tending to the southward; which, aided by the northeast storms, breaking and stirring up the shoals, transports the matters suspended in the river-waters, as well as that portion deposited upon the bottom, away from the outlet of the jetties.

This action has hitherto prevented the growth of the bar, and will preserve it *in statu quo* until the gradual advance of the *dépósitos* from the other mouths of the Danube shall have forced out the littoral current from the ends of the jetties, in which event the latter will have to be extended.

In his first paper, the advocate of the jetty-system for the Mississippi mouths relies upon the action of the waves alone to break up and transport away from the outlet the large mass of *dépósitos*, apparently forgetful of the influence of the waves to form the bar, and that any channel through it is due solely to the river-currents. In all cases, whether a current flows or still water obtains between the jetties, unless the ends of the jetties are founded at such depths that waves cannot act upon the bottom, supposed to be composed of movable material, the tendency of storms is to develop a shoaling.

In a second paper, by the same author, apparently aroused to the important part which it did have in the improvement of the Danube, he asserts that there is a littoral current off the mouths of the Mississippi, and refers for proof of its velocity to page 449 of "Physics and Hydraulics of the Mississippi."

It was impossible to have made a reference more out of place. The subjects treated therein are the ebb and flood tides and the tidal velocities in *mid-river*, but nothing concerning littoral currents.

But the minority report might have referred to a report by Mr. (since Major-General) G. G. Meade, of a survey made by him in 1838, of Southwest and South Passes, and to be found in the work above named, in which, after careful observations conducted from the bar to a distance of seven miles outside, he states that he failed to discover the existence of any littoral current.

Analogy, therefore, between the Danube and the Mississippi, as to the element of a *littoral current*, which was declared so important to its improvement, by the engineers engaged at the former river, falls to the ground. In subsequent portions of this paper I will show that, except the bare fact of both being delta rivers, similarity does not exist between the Danube and the Mississippi.

I shall not in this discussion ignore or reject the facts and conclusions of the survey made by order of the Government, and reported in "Physics and Hydraulics of the Mississippi." This work, elaborate in detail, and remarkable for the clear light which its admirable handling of spe-

cific facts sheds upon the physical laws governing the river, cannot be passed over to receive, in lieu thereof, inconclusive examples taken from foreign rivers.

The published information concerning the Danube, and bearing upon the points in discussion, does not at all compare in scope and scientific value with the exhaustive treatise which we possess upon the Mississippi and its delta. Our engineers, then, can obtain vastly more information from sources within their reach concerning our great river than all the published information available can furnish of the Danube or other foreign river.

The board, in their report of January 13 last, in imitation of the project already extracted from the minority paper of December 6 last, and with the view of submitting its conclusions to a test, adopted the system of parallel jetties for the deepening of the bar at Pass à Loutre. After a careful examination of a chart upon a large scale, compiled from recent surveys, the distance apart of the jetties was assumed to be 2,200 feet, that width corresponding to the width of the pass where the depth of 25 feet was obtained.

The jetties were held strictly to that distance apart, in order that the complete effect of parallel jetties upon the bar might be obtained.

In what follows I will adhere to the principles and conclusions contained in the report of the board, although taking the liberty to discuss the subject in my own way.

1. Assuming that the width of 2,200 feet would suffice to maintain a channel of the required depth in the pass, it would not carry it to the bar, for these reasons: At the bar the wave-action would tend directly to decrease the depth; the intrusion of salt water at certain periods within the jetty-heads would interfere with the normal conditions of scour; the loss of velocity due to great lengths of jetties would exercise an unfavorable influence; and, finally, the occurrence of periods of medium velocities without floods would cause greater deposits upon the bar. The Sulina mouth is a case where it has been attributed to the last-named cause that the navigable depth varied, at periods from 1862 to 1869, between $17\frac{1}{2}$ and $13\frac{1}{2}$ feet. Hence the distance between the jetties must be decreased as the bar is approached.

2. When the jetties shall have arrived at the position of the original outer crest of the bar, it will be found, thanks to the ordinary as well as to the extraordinary advance of the bar, due to the construction of the jetties, that the outer crest has been pushed ahead about 1,800 feet into the Gulf. An ordinary advance of 302 feet per annum, and a moderate period of three years for the construction of about eight miles of jetties, are here supposed.

Owing to the slope at which the bar will advance into the Gulf, the depth on the new outer crest will have decreased between 3 and 4 feet, and hence, in order to maintain the depth of 25 feet, the jetties must be pushed out until the new crest is attained.

Upon the Rhone, when the jetties were completed, in 1852, the bar was about seven-eighths of a mile in advance; in 1863 this advance was nearly one and three-fourths miles; the progress during this interval having been three times the ordinary rate.

The depth on the bar was always much less than that between the jetty-heads, and any partial variation of depth over the bar seemed due to freshets in the river. A littoral current is found of one and one-tenth to one and five-tenths miles per hour. The matter held in suspension and discharged is stated to have been 583,666,666 cubic feet, equivalent

to 36,480,000 tons per annum, of which 137,333,333 cubic feet, or 8,583,333 tons, were carried off by the *littoral current*.

As a comparison, the littoral current at the Sulina mouth is from seven-twelfths to one and one-sixth miles per hour, and the amount of matter yearly discharged through this mouth is about 2,510,000 tons.

The amounts discharged through certain passes of the Mississippi are as follows: Southwest Pass, 67,130,000 tons per annum; Pass à l'outre, 45,975,000 tons per annum; South Pass, 15,810,000 tons per annum.

Although the piers at the Rhone were not carried out *to the bar*, their results have been valuable in demonstrating that the effect of jetties, by concentrating a current upon the bar, would be to increase greatly its rate of advance, while their action upon the depth of the bar was of little benefit and that was confined to times of freshets.

This example is likewise a complete answer to the argument of the minority report, that the jetties, if carried to the outer crest of the bar, would not require continual extension, for the cause therein assigned, that a shoal bar could not again be formed until the deep space ahead, for a distance of two and a half miles, should first have been filled.

The disappointment suffered from the application of the jetty system led to the construction of a lateral canal connecting the Rhone with the Gulf of Foz, and having a depth of 23 feet.

3. Let it be supposed that the jetties, following up the bar, have finally reached its outer crest. Owing to the meeting of the river waters with those of the Gulf, the former will be deflected upward at an angle, a result which is apparent even from considering the lateral spread of these waters after having been released from the confinement of the jetties, and their decrease in depth consequent upon an increase in width.

Now, it is obvious that the materials rolled by the currents upon the bottom will be arrested as soon as they reach this dead angle, or space without currents, and that the upper surface of the new bar will be coincident with the slope at which the river waters incline upward. If this first formation be supposed to take place during a river flood, the bar will progress until the period of slack currents, at which time the deposits will be upon the slope already formed and at its foot. When the next flood comes the waters will be deflected by the slope first formed, and the material deposited upon the slope and at its foot will be carried forward until they reach the new crest, when they will be dropped over to form the exterior slope of the bar. In this mode the bar is formed and continued, and it is evident that as the crest of the slope rises continually in height as it recedes from the jetties, so these must be extended to keep it down, and preserve the proper depth for navigation.

The matters held in suspension by the river waters are mainly carried forward by the currents into the Gulf, where they are deposited, and serve to raise the level of the bottom, but the *bar proper* is composed of materials rolled upon the bottom and arranged in the forms and by the influences already described. The matters carried in suspension by their deposit simply prepare a foundation for the bar, which is afterward regularly constructed upon its surface.

This distinction, which is so clearly made in the "Physics and Hydraulics of the Mississippi," has been little attended to by writers on the subject, and the neglect of it has led to many errors and false notions.

From the view which has been presented of the agencies at work,

which are incessantly tending to diminish the depth, the necessity of converging the jetties, and of so placing and constructing them as to *coerce* and *control* the currents, becomes manifest. These jetties soon cease to be mere margins to the channel, or to act simply as banks of a river; on the contrary, they must be brought into close contact with the currents as well as waves, to resist not only their action, but likewise to compel the currents to perform their necessary work.

The jetties, among other casualties, are exposed to be frequently undermined, and must therefore be founded deep enough to be out of reach of such contingency.

It is not necessary to enlarge; this brief sketch is sufficient to suggest to the engineer the cost as well as difficulties, not merely of commencing a system of jetties upon a foundation proverbial for want of tenacity and resistance, but of prosecuting it to a successful completion, and of making large annual extensions into the Gulf, in the face of the severe storms of the locality.

4. The second minority report, of January 29th last, in dealing with the example proposed by the board, of parallel jetties 2,200 feet apart, which was intended to imitate the system recommended in the first minority report, does not do justice to the report of the board. That report demonstrated that as the *bar* is approached the jetties must be brought closer than the width in the *pass* corresponding to the depth of 25 feet. In other words, that if this width on starting be 2,200 feet, it must be decreased as the jetties are extended.

The decrease of width would bring them into deeper water, and, therefore, make them more costly. But the board did not consider this unfavorable feature of the case in judging of the cost, but treated them as parallel and at the same distance apart as at the start. This certainly was not "elaborately unfavorable" to the jetty system; and if the jetties for the whole or any part of their length did lie in deep water, that must be attributed to the *starting width* between them.

It is obvious this is correct, and, unless in very peculiar local circumstances, the engineer would be in error who should increase such width; but we have seen, on the contrary, that he must decrease it as the jetties lengthen. The author, however, states the board is "erroneous in principle"—for what, in view of this statement, I cannot divine—and even cites the work on "Physics and Hydraulics of the Mississippi," as well as the improvement of the Sulina mouth of the Danube to prove his position. I have looked carefully over these citations, and find that they do not answer the purposes he intended. The question is simply whether, if 2,200 or any other number of feet corresponds to the width of a river having a depth of 25 feet, an increase of that width will not lessen the depth. The board say that it will, and the minority report says, if there is meaning attached to its words, it would not. Such questions cannot be argued.

5. It is evident that, in proportion as the cross-section of discharge on the outer crest of the deposit or bar widens, its progress into the Gulf will become slower, and, on the other hand, if the cross-section be narrowed, the progress of the deposits will become more rapid; whether the relative progress be in the simple inverse ratio of the widths of discharge or in some other, it is not important here to inquire. The essential fact, that as the width of the cross-section diminishes the rate of progress of the bar into the Gulf must increase, is self-evident.

Let us test by this rule the relative advances of the bars at the mouths of the Southwest Pass and South Passes and of Pass à l'Ouvre, each mouth being supposed to be treated with the jetty system, and the

width of cross-section at the end of the jetties being that corresponding to the maintenance of the depths of 25 feet on the passes themselves.

	Southwest Pass.	Pass à Loutre.	South Pass
Natural width of cross-section of discharge into the Gulf...miles	2½	1½	1
Width between heads of jetties.....do.	42	100	1
Ratio between these.....do.	3	4	8
Present annual rate of progress of the bar.....feet	338	302	229
Estimated annual rate of progress of the bars after completion of jetties.....feet	1,014	1,208	2,290

The widths of all these bars have been taken from the Coast Survey map, and upon the same principle of measurements; on account of the smallness of the scale, the dimensions taken are not assumed to be strictly accurate. The width between jetty-heads at Pass à Loutre has been assumed to be 2,200 feet; though at this pass, on account of the abnormal state of things produced by its two mouths, this width apart for the jetties is not so certainly correct as at Southwest Pass and at South Pass. While the estimated annual advance of the bar at Southwest Pass and at Pass à Loutre may be said to be, and probably will be, the same, that for the South Pass is much greater than either.

I do not rely upon this method to furnish accurately the absolute, but it is evidently an approximation to the relative, advances of the bars, to which exception cannot justly be taken, and places the Southwest Pass, therefore, in an unfavorable light for improvement by jetties.

Sir Charles Hartley has said, and in this he has been cited repeatedly by the minority reports, that an outlet having a large discharge was at a disadvantage for improvement with another having a less discharge, on account of furnishing more material for the formation of the bar, and because the bar was usually farther out. This is correct as far as it goes, and it may be true, owing to the littoral current and other peculiarities, for the Danube, to which he particularly applied the principle. But its application to all rivers would lead to grave errors, because another general principle has not been considered, viz, the increased progress forward of a bar due to decreased width of discharge.

The effect of the application of the last rule upon the relative advantages of the Southwest Pass, Pass à Loutre, and South Pass has been to change the aspect of matters as to the choice of the passes for a permanent improvement. The discharge through the Southwest Pass is $\frac{34}{100}$, through Pass à Loutre $\frac{234}{1000}$, and through South Pass only $\frac{10}{100}$ of the whole discharge of the Mississippi; and yet, cut and carve as you will the figures in the table above, the annual progress of South Bar, after the application of jetties, will not be reduced lower than 1½ that of Southwest Bar.

6. An examination of the longitudinal section of the bars will lead to deductions of practical value.

The slopes of the bars interior to the crest give for each depth of water the inclination at which the erosive effect of the currents at that depth and the material of which the bar is composed hold each other in equilibrium. For Southwest Pass, at a depth of 25 feet, this inclination or rise is a little more than 1 foot per 1,000; for Pass à Loutre, the inclination is $1\frac{8}{10}$ feet per 1,000; and for South Pass at least $2\frac{1}{2}$ feet. The slopes of the bar at this pass are very irregular, in strong contrast with the other sections, and seem to indicate intermittent instead of the regular and constant action of the currents prevailing on the other bars.

The growth of the *new bar* beyond the jetty-heads will not be at a less inclination than those above given. Taking, then, the annual advance of Southwest Bar under the action of jetties at 1,000 feet, of Pass à Loutre 1,200 feet, and South Bar at only 1,500 feet, and the diminutions of depths in one year will be respectively 1 foot, 2.16 feet, and $3\frac{1}{2}$ feet; and hence the necessity for annual extensions of the jetties will be more urgent at South Bar than at any other.

A similar relation of slope in the bars will be found by considering the flare* of the mouths of the passes. This element would approximate to the real flare or spread of river-waters as they emerge from the jetty-heads, and give us the means of calculating that slope. It is not assumed that the results given in these methods of obtaining the rise of the bar as it advances into the Gulf are absolutely correct, the scale of the maps available for use being too reduced for that, even if the methods themselves were mathematically correct, which is not pretended to be said. But the results thus furnished will show the approximate relation between the bars in respect to their rise as they advance, and thus enable us to discriminate for or against a certain pass. The three passes having thus been relatively tested as to capacity and eligibility for improvement by jetties, the following results are obtained:

Southwest Pass is the most advantageous, except in the first outlay for jetties, these being about nine miles altogether in length; the advance and vertical rise of the bar-formation are less than in any other; the width between jetties of 3,900 feet, corresponding to the depth of 25 feet, gives it great advantages for permanence, as the necessity for converging these will not, as soon as in the other passes, create such obstruction to discharge that the flowing waters will abandon it for another pass.

Pass à Loutre: The jetties here would not differ materially in length from the preceding example, and the pass is rapidly approximating to Southwest Pass in eligibility; but at present the abnormal state of things arising from its bifurcation and the concavity of one of the jetties toward the currents renders it far inferior to the latter.

As to South Pass, the length of both jetties would be about four and two-thirds miles, but the extension and vertical rise of the bar-formation would be much greater than in the other cases. Its narrow width, between jetties of only 660 feet, would soon be consumed by the convergence necessary to keep up the scour.

The longitudinal section of its bar and bed, by its irregularities, indicates very clearly that the shoaling process is going on throughout, and that the pass at the present time is hanging between the conditions of a *live pass* and a *stagnant ditch*; to the last of which results it must arrive, if a revolution in the delta does not redeem it. And this most probable fate will be precipitated by applying the jetty system to its mouth. The shoal at the head of this pass is permanent, and results from the manner of discharge of the main trunk of the river. The application of works constructed to dissipate this bar would, in such a situation, be precarious, even if at all practicable. Some relief, however, may be possible by dredging or stirring.

The prominent physical features of the Danube are quite different from those of the Mississippi, and it is proper, in concluding this paper, to briefly glance at them. This river separates into two branches at Ismail Chatal, viz, the Kilia and the Toulcha; and the latter, after eleven miles, into two others, the St. George and Sulina branches.

*At the width of pass corresponding to 25 feet in depth.

The distances to the sea from Ismail by the Kilia is ninety-six miles; by the Sulina, seventy-eight miles; and by the St. George branch, ninety miles. The triangle thus formed, having Ismail as its apex, has a base of forty miles along the sea-coast, and a perpendicular of fifty-eight miles.

The first difference between the Danube and Mississippi is, that the former has divided into three long branches, each of which is an active stream; whereas the Mississippi has no branches, but pushes its trunk undivided to the Gulf.

At Isatktcha, fifteen miles above the division, the Danube is 50 feet deep and 1,700 feet wide. At Fort St. Philip, twenty miles above the head of the passes, the depth of the Mississippi is 151 and its width 2,360 feet. Its great depth constitutes another point of difference, which the Mississippi also maintains in its passes.

The average specific gravity of the matter held in suspension in the Danube is 2.5; that of the banks, 2.7; and for the Mississippi the latter element is 1.96. The specific gravity of materials on Southwest Bar, after it had been sifted from finer materials by the action of currents and waves, was 2.6, or about the same as that of the suspended matter in the Danube.

The proportion of silica in the material brought down by the latter river is very large—about 67 per cent.

It is not surprising if we read that at the Sulina mouth large warehouses have been erected on the banks alone as a foundation; that a crib, 30 by 15 feet, sunk off Sulina mouth, and loaded with 130 tons of stone, remained for nearly one week supported on only ten square yards of foundation, without the least settlement, and that the driving of a single pile, 13 inches square, in the line of piers, to a depth of 16 feet, was a day's work for one driver.

Dunes of sand, 30 to 40 feet, are encountered at the Kilia mouths, and of smaller dimensions at those of the St. George.

What a contrast the above offers to the mud-shoals and banks at the mouths of the Mississippi, in which it is said that the weight of a man will send a pole down to a depth of 9 feet. Upon the surface of the bar, where the waves and currents sift out the finer materials, there is of course a deposit of more or less sand. From this brief analysis of physical differences between the two rivers some important deductions may be made. The strength and resistance of its banks is the cause, probably, why, having once separated into three branches, the Danube has been unable to reform its main trunk, or that the cross-section of either branch has not become so great as to convert the others into mere drains for overflow.

In the Mississippi, owing to the nature of its sedimentary deposits, the main trunk cannot be divided, because it has the power always to excavate its bed to the depth and width required to carry off its waters. No crevasse or artificial outlet has ever yet formed a branch to this river.

The same reasoning applies to the passes, which, perforated through the most yielding alluvions, will always suffice to discharge the river, and should one by some obstruction be impeded in its discharge, the others enlarge their cross-sections to supply the emergency.

It is this freedom to discharge under all circumstances which makes it a delicate operation to obstruct the flow of water through any one of the passes, under the plea of improving the navigation. The rapid extension of a pass by jetties, though under all circumstances prejudicial to the discharge through it, would not be so soon felt in its consequences

in the ordinary river; but at the Mississippi delta, such an operation might inure to the rapid deterioration or ruin of the pass, and this is the reason why the application of the jetty system to these mouths must sooner or later wear them out by forcing the waters into other channels. I send here sketches of the Balize bayou, which was the main entrance to the river at the first settlement of the country. These sketches are of 1722, 1724, and 1731. During this interval the pass shrunk in width to the comparative dimensions of a ditch. The rapidity of the change is the striking feature which could not have occurred except in the soil and the other conditions of the Mississippi passes.

The first indication of the change appeared to have been that the outer bar became deep, while the shoal lodged in the pass itself and its juncture with the Southeast Pass.

There are no recognized relics of the delta form, which have in former years occupied successively various positions in the lower portion of the Mississippi. Delta after delta has disappeared, and the question is, how does the trunk, after a certain elongation of the passes, impatient at the obstruction which their lengths offer to a free discharge of its waters, break through into the Gulf and commence a new formation? Such a revolution, impossible where the river empties into a shoal sea, is by no means so when the depth is great. On the other hand, after a certain elongation of the passes, do all the parts move gradually into the Gulf, the head of the passes and trunk, like the brush of a broom at the end of its staff, without breaking their connection? I am aware these questions cannot be answered, except that the delta was once at New Orleans, and is now in its present location. The present age of the delta is at least three hundred years, and the passes are rather long, and if the movement is not gradual, it must suddenly come. No observations, so far as I am aware, have been made with the view of noting any movement.

This is not mere speculation, though it may have that aspect; there is nevertheless a practical side to it. The outlets of the passes are moving at the average rate of 262 feet per annum, and the whole delta must in a certain period of years correspond to the same movement, either gradually or by a sudden burst.

Either view would have an important bearing upon the improvement of the passes by the means of fixed artificial works.

Respectfully submitted.

JOHN NEWTON,

Lieut. Col. of Engineers, Bvt. Maj. Gen.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

—

List of maps accompanying reports upon improvement of the mouths of the Mississippi.

1. *Géologie pratique de la Louisiane*, par R. Thomassy. *Entrée du Mississippi en 1722, 1724, and 1731.* [Map showing the changes which took place at the Balize during the above years.]

2. Map showing the supposed limits of the area in which the center line of the proposed canal would be located, according to Major Warren's idea.

3. Delta of the Mississippi River, from Captain Talcott's survey in 1838, with comparative profiles of Southwest and South Passes.

4. Comparative profiles of the Southwest Pass and South Pass, Delta of the Mississippi River, and of the Sulina branch of the Danube.

5. Sulina mouth of the Danube, from the "Minutes of Proceeding Institution of Civil Engineers, London, Vol. XXI, Session 1861-'62."

6. Comparative chart of the surveys of 1838, 1867, and 1874, of the Southwest and South Passes, Mississippi River, Louisiana.

R 16.

MOUTHS OF THE RHONE.

The following brief account of the application of the jetty system to the mouth of the Rhone, prepared in 1863, was recently communicated to the Chief of Engineers by Mons. E. Malézieux, Engineer-in-Chief in the Corps of Ponts et Chaussées, as affording accurate information on the subject.

[Translation.]

A decree of the 15th January, 1852, ordered the construction of the works for the amelioration of the mouths of the Rhone. The expenditure authorized by the decree was 1,500,000 francs, (\$300,000.)

The work executed for that purpose up to 31st December, 1862, cost 1,464,253.40 francs, (substantially the amount appropriated.)

The works consisted of continuous embankments upon both banks of the Rhone, from the tower of St. Louis to the vicinity of the bar; that on the left bank of the river had a total length of seven kilometres, (22,966 feet,) and terminated 1,530 metres (5,020 feet) inside the crest of the bar. The embankment on the right had a total length of 6,500 metres, (21,326 feet,) and terminated 1,460 metres (4,790 feet) inside the bar-crest. The embankments are composed in part of earthen dikes rising above the surface of water, and in part of jetties of stone that do not rise to the surface. The result of these works has been the confinement of the waters of the Rhone to a single channel running from west-northwest to south-southeast, which at the termination of the embankments has a width of only 400 metres, (1,312 feet.)*

When the concentration of all the waters in one channel was effected, which was at the close of September, 1856, the ends of the jetties were 900 metres (2,953 feet) inside the bar, which was eroded, and from having had a depth upon it of 1.5 metres (5 feet) in July, 1852, was found in September, 1856, to have a depth of 4.15 metres, (13.5 feet.) But since then the bar has moved seaward, and the depth of water upon its crest has diminished, and it has *now* (1863) only a depth of 1.4 metres, (4.6 feet.)

Between June, 1852, and February, 1863, the bar moved 800 metres (2,625 feet) seaward, measured along the line of direction of the embankments. Its mean annual advance since June, 1855, has been 74.35 metres, (244 feet.†)

The variations in the depth of water upon the bar have always taken place at the end of the floods of the Rhone. Floods of no great height

* The width of the Rhone at Arles, the head of the delta, is 600 feet.

† The mean annual advance of all the bars or mouths between 1807 and 1846 was 22 metres, (76 feet.) Memoir of A. Surell, engineer of Ponts et Chaussées, in charge of Rhone works.



AIQE LA

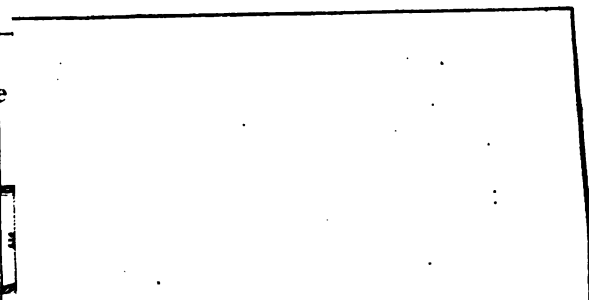
PLANCHE III.

3.

Fig. 3.

rules de boue)





West



caused a shoaling of the bar; floods 4.00 metres (13 feet) in height at Arles (the head of the delta) deepened the bar in some cases and shoaled it in others.

In order to benefit navigation it is essential that the requisite depth in the channel of entrance should be permanently maintained. As it has been proved that the works which have been executed have not produced upon the bar of the Rhone the deepening which the wants of navigation required, and that there was every reason to conclude that in following the adopted system of jetties a definitive improvement in the condition of the entrance could not be effected, it was believed that any further attempt to deepen the entrance to the Rhone should be abandoned.

APPENDIX S.

ANNUAL REPORT OF CAPT. A. N. DAMRELL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1874.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., July 30, 1874.

GENERAL: I have the honor of transmitting herewith annual reports of operations, with financial statements for the year 1873-'74, for the river and harbor improvements under my charge.

Very respectfully, your obedient servant,

A. N. DAMRELL,
Captain of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

S I.

IMPROVING HARBOR AT MOBILE, ALABAMA.

The prosecution of this work was continued during the past year, in accordance with the plan recommended February 14, 1872, by a special Board of Engineers, and under instructions, contained in report of the same Board of Engineers, dated December 11, 1873, approved by the Chief of Engineers.

At the beginning of the year, Mr. John Grant was dredging in Dog River Bar Channel, under an unexpired contract with the United States, until July 3, 1873, when, on the completion of the contract, work was suspended.

As stated in my last annual report, "by act of Congress approved March 3, 1873, a further appropriation of \$100,000 was made for this work, and under date of April 30, 1873, advertisements for proposals were published. On July 1, 1873, seven bids were received and forwarded to the Chief of Engineers."

By order of the Chief of Engineers dated July 16, 1873, the contract was awarded to Mr. John Grant, at 23 cents per cubic yard, measured in the scows, and on the 22d of same month the contract was signed and executed by him, and the dredging in Dog River Bar Channel was resumed in August, 1873.

During the fiscal year ending June 30, 1874, 320,547 cubic yards of material have been excavated from this channel, and the following results obtained: The whole cut was widened to 120 feet with 13 feet water at mean low-tide, 5,200 feet of it to a width of 150 feet, and 5,300 feet to its full width of 200 feet.

It is proposed to continue the widening of Dog River Bar Channel, under the new appropriation of \$100,000, approved June 23, 1874, during the next fiscal year.

In conformity with recommendations contained in my last annual report, authority was granted in letter from the Secretary of War, dated September 30, 1873, to advertise for proposals for reopening Choctaw Bar Channel. Four bids were received and forwarded November 15, 1873, and by letter from the Chief of Engineers, dated November 20, 1873, the contract was awarded to J. E. Slaughter, at 45 cents per cubic yard. December 22 the contract for this work was executed and signed. Dredging in this channel was commenced in January, 1874, and continued until April 2, when, owing to a heavy freshet in the river, the work had to be suspended.

Simultaneously with the commencement of dredging in Choctaw Bar Channel, 400 feet of the dike across Pinto Pass, and 200 feet of jetty at Pinto Point, as recommended by the Board of Engineers in their report dated December 11, 1873, were removed.

During the months of April and May, when the freshet was at its height, frequent soundings in the cut through Choctaw Bar showed, again, a gradual filling up, and the removal of about 300 feet more of the dike at Pinto Pass would have become necessary had not the then existing current through this pass been sufficient to carry away fully that much of it before the necessary arrangements for its removal could be made, so that now we have an opening of 700 feet through the dike, which, in ordinary freshets, I deem ample. In extraordinary freshets, such as we had this spring, and which, perhaps, may not occur again for thirty or forty years, the problem of keeping the cut through Choctaw Bar from filling up still remains to be solved. Current observations, taken at that time, show that the velocity of the current was 3.5 per second in the river, to and a short distance below its mouth, which was sufficient to carry the fine river-sand and mud from above; from there to the newly-formed bar in the cut the velocity of the current diminished to 1.7 per second, and the sand was deposited, the current only being sufficiently strong to carry the lighter particles of mud farther down the bay. Before, however, I shall be able to make any further recommendations for works at this point, more careful and extensive velocity and current observations and soundings must be taken, as upon their result future plans must be based. Early in June the dredge of the contractor, J. E. Slaughter, was ordered back in this channel, and as soon as a width of 120 feet, with 13 feet depth at mean low-tide, through the newly-formed bar, is obtained, dredging under this contract will be suspended on account of the exceedingly high price, and the work will be completed under the new contract, with the approval of the Chief of Engineers.

During the past fiscal year 52,842 cubic yards have been excavated in this channel.

It is proposed to incorporate the completion of this cut into the contract for Dog River Bar, under the new appropriation, as only 18,900 cubic yards remain to be excavated in this channel.

In the month of March, 1874, the removal of the wrecks in Dog River Bar, recommended in my last report, was commenced, and the remains

of the sunken torpedo-boat were entirely removed before the river-freshet compelled me to stop the work, which was, however, resumed again in June last, and will be completed during the month of July, 1874, at a cost not exceeding \$3,500.

Estimate of work remaining to be executed June 30, 1874.

467,700 cubic yards of dredging in Dog River Bar; 18,900 cubic yards of dredging in Choctaw Bar; total, 486,600 cubic yards, at 26 cents.....	\$126,516 00
Removal of wreck in lower gap.....	3,000 00
Contingencies and engineering expenses, 15 per cent	19,427 40

Total	148,943 40
-------------	------------

Amount available July 1, 1874.....	123,185 12
------------------------------------	------------

Estimated amount required for completion of work.....	25,758 28
---	-----------

The improvement of this harbor was commenced in August, 1870, under the late Maj. C. B. Reese, but the original plans and estimates submitted by him were modified, first, by his successor, Col. J. H. Simpson, and, finally, by a Board of Engineers which convened in this city February 3, 1872, and whose recommendations, approved by the Chief of Engineers, have since been carried out. The original estimate of the cost of this improvement, in accordance with plans recommended by the Board of Engineers, is as follows:

Choctaw Bar Channel.....	\$55,307 50
Dog River Bar Channel.....	512,000 00
Removal of wrecks and jetties.....	13,500 00
Contingencies.....	29,040 37

Total original estimate	609,847 87
-------------------------------	------------

APPROPRIATIONS.

Amounts appropriated for improving harbor of Mobile, Ala., since the adoption of the present project:

July 11, 1870.....	\$50,000 00
March 3, 1871.....	50,000 00
June 10, 1872.....	75,000 00
March 3, 1873.....	100,000 00
June 23, 1874.....	100,000 00
Total	375,000 00

Amounts expended during—

Fiscal year 1870-71.....	\$20,714 76
1871-72.....	58,705 39
1872-73.....	61,106 29
1873-74.....	96,945 35

Total	237,471 79
-------------	------------

Amount expended by State Harbor Board.

Dredging on Dog River Bar.....	\$72,025 95
Estimate for completion of work	143,943 40
Probable actual cost of work.....	458,441 14

From this statement it will be seen that the probable actual cost of this work is less by over \$150,000 than the original estimate, which is due to the gradual decrease in the prices paid for dredging from 50 cents per cubic yard in 1870 to 23 cents per cubic yard in 1873.

This work is situated in the collection-district of Mobile, and Mobile is the port of entry.

The amount of revenue collected for the last fiscal year is reported by the collector to be \$96,764.94.

The following statement of the commerce of this port for the last fiscal year has been furnished me by the collector :

The number of vessels that arrived during the year is 188, with a tonnage of 82,050; the number cleared is 164, with a tonnage of 77,624. The total value of export of domestic produce during the same year, \$10,235,293; value of imports, \$333,644.

Abstracts of bids received for this work during the year, and financial statement, are forwarded with this report.

Financial statement.

Balance in Treasury of United States July 1, 1873	\$110,287 34
Amount in hands of officer, and subject to his check, (including \$7,823.94 percentage due on contracts not yet completed)	24,186 22
Amount appropriated by act approved June 23, 1874	100,000 00
Amount expended during the fiscal year ending June 30, 1874	96,945 35
Amount available July 1, 1874	123,186 12
Amount required for the fiscal year ending June 30, 1876	26,000 00

Abstract of bids received and opened July 1, 1873, for dredging Dog River Bar Channel, Mobile Bay, Ala.

No. for reference.	Nature of work.	Names of bidders.	Amount bid for.	Price per cubic yard.	Time of commencing work.	Time of completing work.
1	Dredging Dog River Bar Channel.	John Grant	350,000 cubic yards, more or less.	Cents. 23	(*)	Fifteen months.
2	do	S. N. Kimball	do	23½		Seventeen months
3	do	James E. Slaughter	do	27	(†)	Nineteen months
4	do	Curtis, Fobes & Co.	do	33	On 15th day of August, 1873.	Fourteen months
5	do	Fred. Davis	do	33½	On 1st day of February, 1874.	On 15th day of August, 1874.
6	do	Braxton Bragg	do	34	On 16th day of August, 1873.	On 1st day of June, 1874.
7	do	R. G. Packard	do	34½	(‡)	On 15th day of August, 1874.
					On 1st day of December, 1873.	On 1st day of September, 1874.
						On 30th day of June, 1874.

* Ten days after notification of award of contract.

† Immediately after notification of award.

‡ On 1st day of September, 1873, or within sixty days after contract is signed.

Abstract of bids received and opened October 15, 1873, relating to re-opening of the channel through Choctaw Pass, Mobile Bay, Ala.

No. for reference.	Nature of work.	Names of bidders.	Amount bid for.	Price per cubic yard.	Time of commencing work.	Time of completing work.
1	Dredging in Choctaw Pass.	James E. Slaughter, Mobile, Ala.	36,000 cubic yards, more or less.	\$0 45	Nov. 1, 1873	4 months.
2	do	S. N. Kimball, Mobile, Ala.	do	49	Nov. 1, 1873	60 days.
3	do	T. J. Mowbray, Mobile, Ala.	do	49½	(*)	3 months.
4	do	J. E. Miller, Chicago, Ill.	do	47	Dec. 1, 1873	June 1, 1874.
				60	Jan. 1, 1874	May 1, 1874.

* Within twenty days after notification of award of contract.

S 2.

IMPROVEMENT OF MOBILE HARBOR, ALABAMA.

Report of Board of Engineers.

ARMY BUILDING,
New York, December 11, 1873.

GENERAL: The Board of Engineers constituted by special orders No. 4, paragraph 1, Headquarters Corps of Engineers, January 6, 1872, and reconvened by the following order :

[Special Orders No. 160.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., December 3, 1873.

The following-named officers of the Corps of Engineers, Col. J. H. Simpson, Lt. Col. Z. B. Tower, Lt. Col. H. G. Wright, comprising the board, constituted by special order No. 4, paragraph 1, Headquarters Corps of Engineers, January 6, 1872, will assemble in New York City on the 10th instant, or as soon thereafter as practicable, to consider and report upon questions relating to the improvement of the harbor of Mobile, Ala., which will be presented by letter of instructions from this Office.

By command of Brigadier-General Humphreys.

THOS. LINCOLN CASEY,
Major of Engineers.

Met in New York December 10, 1873, all the members present.

The following are the instructions of the Chief of Engineers contained in his letter of December 3, 1873, to the senior member of the board :

The attention of the board is particularly requested to that portion of the report of Captain Damrell having reference to the jetties at Pinto Pass and Pinto Point, and to his recommendation that an opening of from 400 feet to 500 feet be made in the former, and that 200 feet be removed from the latter. The attention of the board is also invited to the report of the Board of Engineers on the improvement of the harbor of Mobile, printed in the Report of the Chief of Engineers for 1872, pages 589 to 597.

The board will investigate the questions and recommendations submitted by Captain Damrell, and report its views thereon, together with such recommendations in regard to the improvement of the harbor of Mobile as in its judgment may be necessary.

After an examination of the report dated September 16, 1873, of the officer in charge of the work, Capt. A. M. Damrell, Corps of Engineers, and a study of the drawings accompanying it, showing changes that have taken place in the Choctaw Channel at the entrance to Mobile Inner Harbor, and a review of their own report, made February 14, 1872, on the improvement of this channel, this board have the honor to present the following views and conclusions in reference to the questions submitted for their consideration :

The board in February, 1872, investigated the subject of the improvement of the channel of entrance to Mobile Harbor, approving the method, then in progress, that had been proposed by the officer in charge, Colonel Simpson, Corps of Engineers, and by previous boards. They also examined the method for effecting the same end, as proposed by the engineer of the State Board, and gave it as their opinion that the more important of these works would certainly effect a change of the regimen of the river, and would be detrimental ; in fact, that any of their dikes or jetties that should result in scour to the river banks or bottom would probably fill up the channel of entrance, which at that time was being dredged by the United States engineers. They therefore objected posi-

tively to the partial closing of the Tensaw and Spanish Rivers, and those works were not prosecuted.

With regard to the closing of Pinto Pass, which was at that time approaching completion, they remarked as follows :

There will be some increase to the volume of water flowing out of the mouth of Mobile River by shutting up this pass, producing, probably, some scouring effects below on the river banks or bottom, the heavier or sandy portions of which, if this increased flow of water be rapid enough to move sand, will be re-deposited as soon as the slack-water will permit, while the finer portions will be carried farther out into the bay, and mostly dispersed in its shallow waters on Dog River Bar, and beyond. And here it may be well to observe that any scouring process that moves materials from the banks or bottom of a river near its mouth, only transfers it into the bay or sea beyond, to form a bar there, if the water be shoal. Any large increase in the flow of Mobile River will probably move Choctaw Bar farther toward the bay, and result in injury to the works now in progress. This bar is nearly all sand, and no current in the upper part of the bay is rapid enough to disperse it. The aim of all works of improvement at this locality should be to avoid such operations as lead to the movement of sand to the mouth of the river. In fact, the deepening of Mobile River by the scouring process ~~seems incompatible with the preservation of the channel through Choctaw Bar, as now in progress of execution.~~ It is questionable, however, if this dike will create any such serious disturbance in the river, and this board do not, therefore, make a point of objecting to its construction, any further than noticing its possible detriment to the excavations on the bar below. If these excavations had not been commenced the board would not have thought it necessary to have presented any remarks as to the closing of Pinto Pass.

As will be seen from the foregoing extract, the board, while apprehensive that the closing of Pinto Pass might be injurious to the Government works in progress on the bar below, did not make the same objection to it as to the closing, with the exception of a passage for vessels, of the much larger outlets of Spanish and Tensaw Rivers. The extent of the injury apprehended could not be foreseen, and it was quite possible it might be so slight as to be disregarded ; and as the work had not only been commenced but had been carried far toward completion, it was thought well to permit of its being finished. Had it not been commenced the board would certainly have objected to its construction.

From the data presented by the officer in charge of the works of improvement at Mobile harbor it appears that the closing of Pinto Pass has resulted in a scour of the river below, carrying a portion of the sand thus moved into the channel excavated by the United States Government, and it is therefore recommended that a part of the dike shutting up this pass be removed, as suggested by Captain Damrell, to be followed by further removals if found necessary.

As to the Pinto Point Jetty, it is very questionable if this work alone would have been detrimental, but it has probably proved somewhat so in connection with the closing of the pass above. Whether it will continue to exercise an injurious influence after the re-opening of the pass seems doubtful ; but in view of this uncertainty the board is inclined to recommend the removal of 200 feet of the lower extremity, as suggested by Captain Damrell, to be followed by a further removal if then judged necessary.

The board further recommend that close and continued observation by soundings, examinations of the bottom, determination of current, velocity, and otherwise, be made to ascertain if either of the obstructions, upper or lower, produce any injurious effect upon the artificial channels, or upon the natural passage-way connecting them. It is possible that these obstacles may check the outward current-velocity so as to cause the deposit of sediment in these channels.

In their previous report this board thought from an examination of the sands of the bottom that the yearly process of shoaling on Choctaw Pass and Bar might be due in part to the wash along Garrow's Bend

around Choctaw Point, and therefore they approved of jetties along the shore of the bend to arrest the inward motion of these sands. They now recommend that examinations be made of the sand on Choctaw Bar, and also soundings around Choctaw Point after southeast storms, to ascertain if these storms cause any movement of sands into the mouth of Mobile River and into the Choctaw Channel, now that the jetties have been built along Garrows Bend.

The board have no further suggestions to make in connection with the improvement of the bay and harbor of Mobile.

The papers and drawings referred to the board in connection with this subject are herewith returned.

Respectfully submitted.

J. H. SIMPSON,
Colonel of Engineers, and Bvt. Brig. Gen., U. S. A.
Z. B. TOWER,
Lieut. Col. of Engineers, and Bvt. Maj. Gen.
H. G. WRIGHT,
Lieut. Col. of Engineers, and Bvt. Maj. Gen.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

S 3.

IMPROVING HARBOR OF CEDAR KEYS, FLORIDA.

Proposals for dredging 10,000 cubic yards, more or less, in the main ship-channel, harbor of Cedar Keys, were advertised for during the year. Three bids were received, but not accepted.

The operations contemplated for the year 1874-'75 are: Dredging 10,000 cubic yards, more or less, at the mouth of the harbor of Cedar Keys, Fla.

No appropriation was made for the fiscal year ending June 30, 1875.

Financial statement.

Balance in Treasury of United States July 1, 1873.....	\$7,500 00
Amount expended during the fiscal year ending June 30, 1874.....	44 41
Amount available July 1, 1874.....	7,455 59
Amount required for the fiscal year ending June 30, 1876	30,000 00

Abstract of bids received and opened May 30, 1874, relating to dredging in the main ship-channel, harbor of Cedar Keys, Fla.

No. for reference.	Nature of work.	Names of bidders.	Amount bid for.	Price per cubic yard.	Time of commencing work.	Time of completing work.
1	Dredging in the main ship-channel, harbor of Cedar Keys.	James E. Slaughter, Mobile, Ala.	10,000 cubic yards, more or less.	\$0 74½	Not specified	Jan. 1, 1875
2	do	S. N. Kimball, Mobile, Ala.	do	75	do	Jan. 31, 1875
3	do	W. T. Hatton, Mobile, Ala.	do	90	July 1, 1874	Nov. 1, 1874

S 4.

IMPROVEMENT OF CHOCTAWHATCHEE RIVER, FLORIDA AND ALABAMA.

No appropriation was made for the improvement of this river for the last fiscal year.

By act of Congress approved June 23, 1874, \$5,000 were appropriated for this work.

It is proposed to apply this amount to the removal of snags and overhanging trees, beginning at the mouth of the river and working up as far as the appropriation will allow.

The original estimate for this work, as recommended by my predecessor, Col. J. H. Simpson, in his report dated April 6, 1872, is as follows:

Snag-boat and appurtenances.....	\$2,500
Working same for five months.....	15,000
Removing overhanging trees.....	6,750
Superintendence five months.....	500
Subsistence of men.....	1,860
Removing wrecks of two steamers.....	2,000
Engineering and contingencies, 20 per cent.....	5,722
Total	34,332

Financial statement.

Amount appropriated by act approved June 23, 1874.....	\$5,000
Amount available July 1, 1874.....	5,000
Amount required for the fiscal year ending June 30, 1876.....	10,000

S 5.

IMPROVEMENT OF APALACHICOLA RIVER, FLORIDA.

No appropriation was made for the last fiscal year.

By act of Congress approved June 23, 1874, \$10,000 were appropriated for this improvement.

It is proposed to apply this amount to the removal of dangerous snags, and any remaining balance to improving Moccasin Slough, on this river.

The original estimate of cost of improving this river, as shown in my last annual report, is as follows:

Widening and straightening of Moccasin Slough.....	\$15,000 00
One-third cost of snag-boat, (\$100,000).....	33,333 33
Service of snag-boat for one season of six months, at \$5,000 per month...	30,000 00
Contingencies, &c.....	2,000 00
Total	80,333 33

Financial statement.

Amount appropriated by act approved June 23, 1874.....	\$10,000 00
Amount available July 1, 1874.....	10,000 00
Amount required for fiscal year ending June 30, 1876.....	20,000 00

S 6.

IMPROVEMENT OF CHATTAHOOCHEE AND FLINT RIVERS, GEORGIA.

No appropriation was made for the last fiscal year.

By act of Congress approved June 23, 1874, \$25,000 were appropriated for this improvement.

INDEX.

	Pages.	
	Part I.	Part II.
A.		
Accotink Creek, Va., improvement of	83	29
Ahnepee, Wis., harbor of	38	143
Alton Harbor, Ill	60	324
Angelina River, Tex	74	742
Apalachicola River, Fla., improvement of	75	896
Appomattox River, Va., improvement of, below Peters- burgh	86	46
Aquia Creek, Va., improvement of	84	37
Arkansas, Missouri, and Mississippi Rivers, improvement of ..	62	368
Aroostook River, Me., survey for improvement of	116	327
Ashtabula, Ohio, harbor of	51	223
Atchafalaya River, La., survey of	74	771
Au Sable, Mich., harbor of	46	201
B.		
Baltimore, Md., harbor of	81	17
Battalion of engineers	32	
Battle-fields and campaigns, maps of	121	476
Bayou La Fourche, La., survey of	74	765
Big Sodus, N. Y., harbor of	54	253
Black Lake, Mich., harbor of	44	187
Black River, Ohio, harbor of	49	220
Black River, N. Y., mouth of	55	268
Black River, Saint Clair River, Mich, mouth of	47	212
Black Hills, Dakota and Wyoming, reconnaissance of	125	628
Block Island, R. I., construction of harbor at	99	240
Boards of engineers for fortifications	29 32	
Boston, Mass., harbor of	111	313
Broadkill River, Del., improvement of	93	142
Bridge across the Genesee River at Charlotte, N. Y	71	583
Bridge (pontoon) across the Mississippi River at Prairie du Chien	71	620
Bridge across the Mississippi River at Saint Louis, Mo	71	636
Bridgeport, Conn., harbor of	102	265
Bridging the channel between Lakes Huron and Erie	71	587
Brunot's hydraulic gates	65	475
Buffalo, N. Y., harbor of	52 226	229
Burlington, Vt., harbor of	56	274
C.		
Calcasieu Pass, La., improvement of	73	721
Calumet, Ill., harbor of	41	159
Cambridge, Md., harbor of	82	24
Camden Harbor, Me., improvement of	107	302
Canal from Donaldsonville, La., to Rio Grande River	74	
Canal, (ship,) Mississippi River and Gulf of Mexico	74	776
Cape Fear River, N. C., improvement of, below Wilmington ..	88	68
Cedar Keys, Fla.	75	895
Channel between Staten Island and New Jersey, improve- ment of	96	168

	Pages.	
	Part I.	Part II.
Charleston Harbor, S. C., improvement of ship-channel in...	76	3
Charlotte, N. Y., harbor of	54 247	
Chattahoochee River, Ga. and Fla.	76 896	
Cheboygan, Mich., harbor of	46 200	
Chesapeake and Ohio Canal, survey for extension of	67 493	
Chester River, Md., improvement of, at Kent Island Nar- rows	81	17
Chicago, Ill., harbor of	40 155	
Choctawhatchie River, Fla. and Ala., improvement of	75 896	
Cleveland, Ohio, harbor of	50 222	
Cleveland, Ohio, harbor of refuge at	53 232	
Cochecho River, N. H., improvement of	109	309
Cohansey Creek, N. J., improvement of	93	144
Columbia River, Lower, Oreg., improvement of	117	355 362
Columbia River, Upper, Oreg., improvement of	117	358 364
Conneaut, Ohio, harbor of	51 224	
Connecticut River above Hartford, Conn., improvement of ..	101	249
Connecticut River below Hartford, Conn., improvement of ..	100	248
Coquille River, Oregon, survey of mouth of	118	364
Crow Shoals, Delaware Bay, survey of	93	146
Cumberland River, Tenn., improvement of	70	577
Cypress Bayou, Texas, improvement of	73 706	
D.		
Defenses, sea-coast and lake frontier	4	
Delaware River below Fort Mifflin Bar, improvement of	92	140
Delaware River at Horse-Shoe Shoals, improvement of	92	141
Delaware River between Trenton and Bordentown, N. J., im- provement of	92	142
Detroit River, Mich., improvement of	47 213	
Des Moines Rapids, Mississippi River, improvement of	59 303	
Du Luth, Minn., harbor of	35 131	
Dunkirk, N. Y., harbor of	52 225	
Duxbury, Mass., harbor of	115	322
E.		
Eagle Harbor, Mich.	36 135	
East Chester Creek, N. Y., improvement of	95	166
East River, N. Y., removal of obstructions from	94	160
Edgartown Harbor, Mass.	96	182
Elizabeth River, Va., improvement of South Branch of	96	57
Elk River, Md., improvement of and examination of	79 89	15 81
Engineer depots	32 34	
Erie, Pa., harbor of	51 224	
Explorations and surveys in the Division and Department of the Missouri	123 124	607 622
Explorations, geographical, &c., west 100th meridian	122	480
Explorations, geological, 40th parallel	122	177
Explorations and reconnaissances	123	
Explorations and reconnaissances, estimates for	126	
Explorations and surveys in Department of the Platte	124	620
Explorations and surveys in Division of the Pacific	126	626
F.		
Fall River, Mass., survey and improvement of harbor of	98 103	225 294
Falls of Saint Anthony, Minn., preservation of	57 277	
Falls of the Ohio River, improvement of navigation at	67 566	
Flint River, Ga. and Fla.	76 896	
Fortifications	6	

	Pages.	
	Part I.	Part II.
Fort Saint Philip Canal.....	74	741
Fort Mifflin Bar, Delaware River, improvement at.....	92	140
Forked Deer River, Tenn., survey of.....	63	372
Fox and Wisconsin Rivers, improvement of.....	42	161
Frankfort, Mich., harbor of.....	42	174
G.		
Galena River, Ill., survey of.....	58	289
Galveston Bay and Harbor, improvement of and survey of..	73 721 722	
Geological exploration 40th parallel	122	477
Gloucester, Mass., harbor of.....	111	311
Grand Haven, Mich., harbor of.....	44	184
Grand River, Ohio, harbor of.....	51	222
Great Kanawha River, improvement of.....	66	483
Green Bay, Wis., harbor of.....	37	139
H.		
Harbor of refuge, Lake Huron.....	47	209
Harbor of refuge, Sturgeon Bay Canal, Wis.....	38	141
Harlem River near East River, N. Y., improvement and survey of.....	95 96	165 169
Hell-Gate, N. Y., improvement of navigation at.....	94	160
Hodgkin's Cove, Ipswich Bay, Mass., survey at.....	116	345
Horseshoe Shoals, Delaware River, improvement of.....	92	141
Housatonic River, Conn., improvement of.....	102	261
Hudson River, N. Y.....	94	154
Huron, Ohio, harbor of.....	49	218
Hyannis, Mass., harbor of.....	96	180
Hydraulic gates and movable dams.....	65	415
I.		
Illinois River, improvement of.....	60	317
Ipswich Bay, Mass., survey for breakwater at.....	116	345
Irrigation of the Joaquin, Tulare, and Sacramento Valleys, Cal.....	126	
J.		
James River and Kanawha water-line.....	89	86
James River, Va., improvement of.....	85	38
K.		
Kanawha River, Great, improvement of.....	66 483	
Kennebec River, Me., improvement of.....	107	303
Kenosha, Wis., harbor of.....	40	153
Kent Island Narrows, Md., improvement of	81	17
L.		
Lake harbors.....	35	
Levees of the Mississippi River.....		380
Lewes, Del., construction of pier at.....	90	130
Little Sodus, N. Y., harbor of.....	54	255
Louisville and Portland Canal, enlargement of.....	67	566
Ludington, Mich., harbor of.....	43	178

	Pages.	
	Part I.	Part II.
M.		
Machias River, Me., improvement of.....	104	295
Manistee, Mich., harbor of.....	43	176
Manitowoc, Wis., harbor of.....	39	145
Maps of campaigns and battle-fields.....	121	476
Marcus Hook, Pa., harbor of.....	91	135
Marquette, Mich., harbor of.....	37	137
Matagorda Bay entrance, Texas.....	74	760
Meeker's Island, Minn., lock and dam at.....	58	287
Menomonee, Mich. and Wis., harbor of.....	37	138
Merrimac River, Mass., improvement of.....	110	310
Michigan City, Ind., harbor of.....	41	160
Milford, Conn., harbor of.....	101	260
Milwaukee, Wis., harbor of.....	40	150
Minnesota River, improvement of.....	58	288
Mississippi, Missouri, and Arkansas Rivers, improvement of.....	62	368
Mississippi River, between mouths of the Illinois and Ohio Rivers, improvement of.....	60	324
Mississippi River levees.....	380	380
Mississippi River and Gulf of Mexico Ship-Canal.....	74	776
Mississippi River, mouths of, improvement of.....	72	682
Mississippi River, Upper, improvement of.....	59	301
Mississippi River between Saint Cloud and Falls of Saint Anthony, survey of.....	58	298
Mobile, Ala., improvement of harbor of.....	75	889
Monongahela River, improvement of.....	65	481
Monroe, Mich., harbor of.....	48	215
Muskegon, Mich., harbor of.....	44	182
Military road from Santa Fé to Taos, New Mexico.....	125	625
Military and geographical survey, estimates for.....	126	
N.		
Nansemond River, Va., improvement of.....	87	63
Narraguagus River, Me., improvement of.....	105	297
Neches River, Tex.....	74	742
New Buffalo, Mich., harbor of.....	41	
Newburyport, Mass., harbor of.....	110	310
New Castle, Del., construction piers at.....	90	134
New Haven, Conn., harbor of.....	101	257
Newport, R. I., harbor of.....	98	225
Nomini Creek, Va., improvement of.....	85	38
Northeast River, Md., improvement of.....	79	14
Norwalk River, Conn., improvement of.....	102	268
O.		
Oakland Harbor, San Francisco Bay, improvement of.....	119	378
Oak Orchard, N. Y., harbor of.....	53	243
Occoquan Creek, Va., improvement of and survey of.....	83	29
Office of the Chief of Engineers.....	127	
Officers of the Corps of Engineers.....	3	
Ogdensburg, N. Y., harbor of.....	55	269
Ohio River, improvement of.....	64	400 410
Olcott, N. Y., harbor of.....	53	238
Old House Channel, Pamlico Sound, survey of.....	89	84
Ontonagon, Mich., harbor of.....	36	134
Oostenaula River, Ga., examination of.....	70	581
Osage River, Mo., improvement of.....	61	338
Oswego, N. Y., harbor of.....	55	261
Otter Creek, Vt., improvement of.....	57	276
Ouachita River, Ark. and La., improvement of and survey of.....	61	348 352

	Pages.	
	Part I.	Part II.
P.		
Pamlico Sound, N. C., survey of channel in.....	89	84
Pascagoula, Miss., survey at harbor of.....	74	754
Passaic River, N. J., improvement of.....	95	165
Patapsco River, Md., improvement of.....	81	17
Pawcatuck River, R. I. and Conn., improvement of.....	100	243
Pawtucket River, R. I., improvement of.....	98	227
Peconic River, Long Island, N. Y., improvement of.....	103	271
Penobscot River, Me., improvement of and survey of.....	106	116 299
Pent Water, Mich., harbor of.....	43	179 331
Père Marquette, harbor of, (see Ludington).....	43	178
Plattsburgh, N. Y., harbor of.....	56	274
Plymouth Harbor, Mass., improvement and survey of.....	115	117 323 348
Port Chester, N. Y., harbor of.....	95	167
Port Clinton, Ohio, harbor of.....	48	217
Port Jefferson, Long Island, N. Y., harbor of.....	103	270
Portland, Me., harbor of.....	108	304
Portsmouth Harbor, N. H., survey for breakwater.....	116	342
Port Warden's line at Philadelphia.....	93	145
Port Washington, Wis., harbor of.....	39	149
Point Judith Lake, R. I., survey of outlet of.....	103	286
Providence River, R. I., improvement of.....	99	237
Provincetown, Mass., harbor of.....	115	325
Public buildings, grounds, and works, District of Columbia.....	120	385
Pultneyville, N. Y., harbor of.....	54	249
Q.		
Queenstown, Md., harbor of.....	80	16
R.		
Racine, Wis., harbor of.....	40	152
Rappahannock River, Va., improvement of, below Fredericksburgh.....	84	29
Raritan River, N. J., survey of.....	96	173
Reconnoissances and explorations.....	123	
Red River of the North, Minn., survey of.....	58	295
Red River Raft, removal of.....	72	702
Red-Fish Bar, Galveston Bay.....	73	740
Richmond's Island, Me., harbor of refuge at.....	109	306
Rincon Rock, Harbor of San Francisco, Cal., removal of.....	119	371
River and harbor improvements.....	34	
Roanoke River, N. C., improvement of, below Weldon.....	88	64
Rock Island Rapids, Mississippi River.....	59	311
Rocky River, Ohio, harbor of.....	50	221
Rondout, N. Y., harbor of.....	95	167
Rhone, France, jetties at the mouth of.....	74	888
S.		
Saco River, Me., improvement of.....	109	307
Saginaw River, Mich., improvement and survey of.....	46	205 206
Saint Anthony, Falls of, Minn., preservation of.....	57	277
Saint Clair Flats Ship-Canal.....	47	211
Saint Croix River, Me., improvement of.....	104	290
Saint Francis River, Ark. and Mo., improvement of.....	63	371
Saint John's River, Fla., improvement of bar at mouth of.....	78	8
Saint Joseph's, Mich., harbor of.....	45	194
Saint Louis, Mo., improvement of harbor of.....	60	325
Saint Mary's Falls Canal, Mich.....	45	196
Saint Mary's River, Mich.....	46	198

Wabash River, Ind., improvement
 Wabash River, Ark. and La., improvement of
 Waddington, N. Y., harbor of
 Wareham, Mass., harbor of
 Washington and Georgetown, D. C., improvement of
 Washington aqueduct, D. C.

	Pages.	
	Part I.	Part II.
Water-gauges on Mississippi and tributaries.....	67	487
Wellfleet, Mass., harbor of.....	115	324
Wells Harbor, Me., improvement of	109	208
White River, Ark., improvement of	63	371
White River, Mich., harbor of.....	43	180
Wickford Harbor, R. I., improvement of	99	239
Wicomico River, Md., improvement of.....	82	24
Willamette River, Lower, Oregon, improvement of	117	351
Willamette River, Upper, Oregon, improvement of	117	357
Wilmington, Cal., construction of breakwater at.....	118	369
Wilmington, Del., harbor of.....	91	136
Wisconsin and Fox Rivers, improvement of.....	42	161
Wood's Hole, Buzzard's Bay, Mass., survey at.....	103	275
Worton, Md., harbor of.....	80	16
Y.		
Yamhill River, Oregon, survey of.....		364
Yazoo River, Miss., removal of wrecks in.....	62	364
Youghiogheny River, Pa., survey of.....	67	558



